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FUNCTION OF INTERTRIAL INTERVAL IN MATCHING-TO-SAMPLE[1]

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Twelve pigeons were trained on matching-to-sample using either a 0-, 5-, 15-, 25-, or 60-sec intertrial interval. Eight of these 12 pigeons were given one of the following intertrial interval changes: 0 to 60, 0 to 5, 5 to 0, 60 to 0, 15 to 25, 5 to 15, 60 to 5, 5 to 1, 1 to 5, 1 to 25, and 25 to 1 sec. Most intertrial interval changes were repeated at least once. The 0-sec intertrial interval subjects failed to match beyond chance levels, while other intertrial interval values resulted in matching acquisition. Changes from 0 sec to other intertrial interval values increased and changes to 0 sec decreased matching performance. Changes to intertrial interval values other than 0 sec resulted in little change in matching accuracy once stable performance had been attained.

Matching-to-sample is an operation in which reinforcement is dependent upon responses to comparison stimuli that match that of a standard stimulus. Research on matching-to-sample tasks has dealt not only with variables such as timeout (Zimmerman and Baydan, 1963), pretimeout stimuli (Miller and Zimmerman, 1966), observing responses (Eckerman, Lanson, and Cumming, 1968), and schedules of reinforcement (Ferster, 1960), but also with the use of this procedure as a baseline from which effects of drugs (Berryman, Cumming, and Nevin, 1963), hypnosis (Ferster, Levitt, Zimmerman, and Brady, 1961), and brain lesions (Spaet and Harlow, 1943) may be examined. The use of matching-to-sample as a baseline requires that there be little variability in the matching performance. The aforementioned variables have been found to affect either rate or accuracy. Intertrial interval (ITI) is an additional temporal variable that may influence number of trials to criterion, final performance reached, and stability of final performance. Although little is known about the effect of intertrial interval on acquisition, different ITI values have been used within the same subject, (Nevin, Cumming, and Berryman, 1963; Jenkins, 1961; and Cumming, Berryman, Cohen, and Lanson, 1967) and between experiments using otherwise comparable procedures. For example, Nevin, *et al.*, (1963) used a 1-sec ITI; Eckerman *et al.*, (1968) used a 25-sec ITI, and Cohen (1969) used a 15-sec ITI. If intrasubject and inter-experimental comparisons are to be made, it would seem necessary to determine what effect different ITI values have on matching behavior.

METHOD

Subjects

Twelve White King pigeons, approximately 3 yr old, were maintained within 15 g of 80% free-feeding weights on a grain mixture consisting of 62% cracked corn, 19% wheat, 18% milo, and 1% oats.

Apparatus

A BRS-Foringer pigeon test chamber contained three plastic translucent pecking keys transilluminated by three IEE light projecting display cells (Model 1346). A filtered air intake and exhaust fan served as masking noise. All aspects of the experimental procedure were automatically controlled by BRS-Foringer relay circuitry.

Procedure

Preliminary training. After magazine training, the response requirement was increased to a fixed ratio of five responses (FR 5) on the center key, which was alternately illuminated with three hues (amber, red, and green). Responses on the illuminated key were reinforced with 3-sec grain magazine presentation. No

[1]Thanks are due to my wife, Valerie Holt, for her invaluable cooperation in compiling these data. Reprints may be obtained from Gary L. Holt, Department of Psychology, Eastern Illinois University, Charleston, Illinois 61920.

timeout or ITI was presented. After the pecking response was well established on the center key, pecks on any illuminated, randomly presented, comparison key were reinforced.

Preliminary training was terminated when subjects pecked the illuminated key with short latency regardless of hue. On the following day, the simultaneous matching procedure was employed.

Simultaneous matching procedure. At the start of a trial, a hue was presented on the center key. A peck on the center key produced a comparison hue on each of the two side keys. A peck on the key of corresponding hue terminated the standard and comparison stimuli and operated a grain magazine for 3 sec. An incorrect match terminated all lighted keys and houselights for a 2-sec timeout. All responses on all keys during the timeout were ineffective. The 2-sec timeout was followed by a 0-, 5-, 15-, 25-, or 60-sec ITI; then, the same trial was presented again, *i.e.,* a correction trial. During the ITI, all keys were dark, the houselight remained on, and responses on all keys were ineffective. Throughout the acquisition phase, the ITI was varied among subjects as indicated above. Following a correct response and the ITI, the next condition in the 12-condition sequence was begun. The sequence of presentation of the 12 stimulus conditions was arranged according to a randomized block that was repeated 12 times in each of the 144 trial sessions (see Table 1).

Each subject was given 144 trials per session in addition to 12 warm-up trials at the start of each session. The warm-up trials were not included in the data. Only the first response on each trial, whether correct or incorrect, was recorded.

Table 1

Stimulus Conditions

Conditions	*Left Key*	*Center Key*	*Right Key*
1	Amber	Red	Red*
2	Red	Blue	Blue*
3	Red*	Red	Blue
4	Blue	Amber	Amber*
5	Red	Amber	Amber*
6	Amber*	Amber	Red
7	Blue*	Blue	Red
8	Amber	Blue	Blue*
9	Amber*	Amber	Blue
10	Blue	Red	Red*
11	Blue*	Blue	Amber
12	Red*	Red	Amber

*response reinforced

Table 2

Order of exposure to intertrial interval values and number of sessions at each value.

Bird Number	
3	0(32)*, 60(35), 0(16), 60(6), 5(2), 0(3).
12	0(31), 60(26), 0(20), 60(5), 5(3), 0(5).
4	0(45), 5(12), 0(8), 5(5), 0(4).
11	5(35), 0(28), 5(14), 0(5), 5(4), 1(2), 5(4).
8	60(40), 0(7), 60(7), 0(18), 60(9), 0(6), 60(7).
5	15(45), 25(13), 15(4), 1(4), 25(4), 1(4), 25(3).
17	15(45), 25(10), 15(5), 1(4), 25(3).
18	5(45), 15(8), 5(6), 15(9).

*Intertrial interval of 0 sec for 32 sessions, followed by an ITI of 60 sec for 35 sessions, *etc.*

During initial acquisition, 12 subjects were placed on the following ITIs; Birds 3, 4, 12, and 21 on 0 sec; 11 and 18 on 5 sec; 5 and 17 on 15 sec; 6 and 9 on 25 sec; 8 and 19 on 60 sec. After acquisition, systematic changes were made within eight subjects between at least two different ITI values. These are summarized in Table 2.

Subjects 6, 9, 19, and 21 were used only to study acquisition.

RESULTS

Figures 1A, B, C, and D show acquisition of correct responding for two subjects under each of the ITI values.

The difference in acquisition rate and terminal performance between most 5-, 15-, 25-, and 60-sec ITIs and 0-sec ITI conditions appears reliable. The 0-sec birds seldom performed above chance. Acquisition rate and terminal performance differed between two 5-sec birds. Bird 11, under a 5-sec ITI, showed rapid acquisition to approximately 85% correct in 14 sessions, while Bird 18, also under a 5-sec ITI, matched at approximately 50%. Birds 4 and 21, under a 0-sec condition, seldom responded above chance levels throughout 45 sessions. The birds exposed to an ITI of 15 sec showed similar acquisition functions. Both birds under 25-sec ITIs, (Figure 1C), showed acquisition to 80% in approximately 13 sessions, with consistent terminal performance of about 90% for Birds 6 and 9. Terminal matching performance with 60-sec ITIs, also showed consistently high matching.

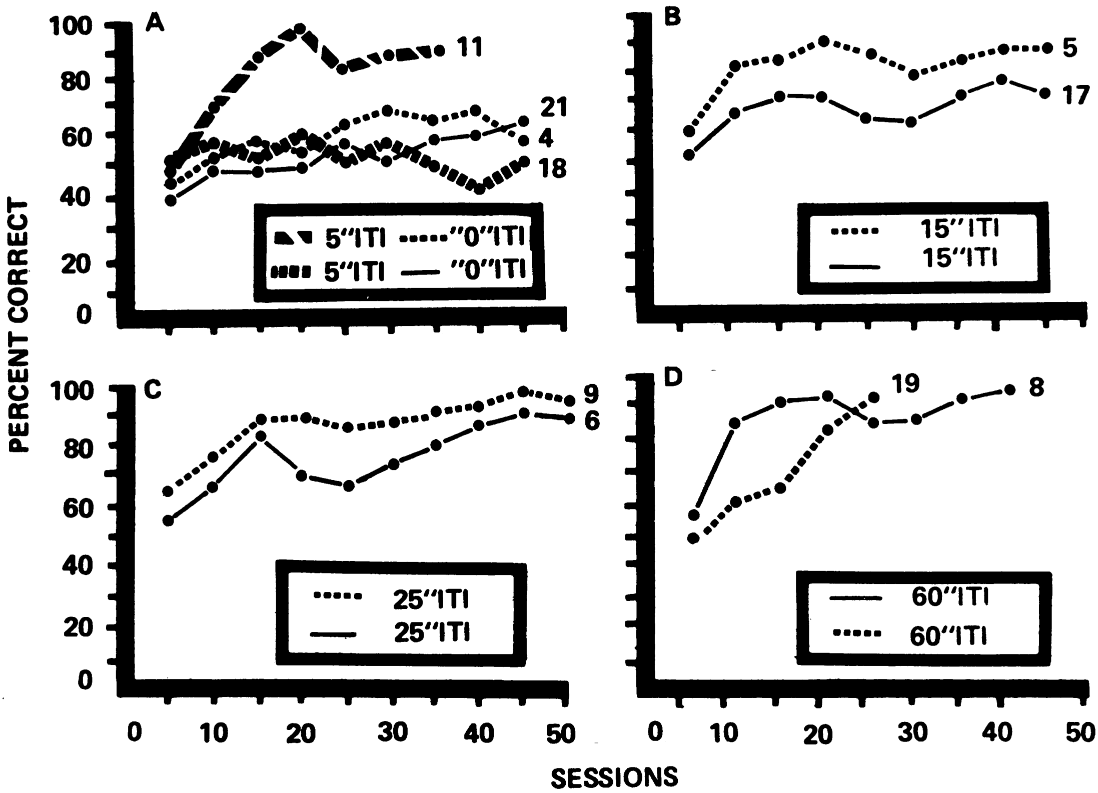

Fig. 1. Acquisition of matching-to-sample performance as a function of intertrial interval (ITI).

Figures 2A, B, and C show repeated changes from 0-sec ITI baselines to a 60-sec (Birds 3 and 12) and a 5-sec ITI (Bird 4). Each change increased matching accuracy from chance levels under 0-sec ITIs to approximately 85% to 90% correct under 5-sec and 60-sec ITIs. Zero-second ITIs tended to reverse the percentage of matching to near chance accuracy. The increase in matching accuracy following the change from 0-sec to 60-sec and 5-sec conditions was repeatable between subjects (Birds 3 and 12) and within subjects (Birds 3, 12, and 4). The 5-sec ITIs resulted in little effect when introduced after 60-sec baselines. Thus, small as well as large ITIs increased correct responding, while 0-sec ITIs decreased matching.

Figures 2D and E show the effect of 0-sec ITI after stable responding had been obtained on a 5-sec baseline (Bird 11) and a 60-sec baseline (Bird 8). The 0-sec condition resulted in only a 4% decrease in accuracy with the 5-sec baseline but a 25% decrease with the 60-sec baseline. Matching accuracy also became more variable when 0-sec ITI changes were introduced. A change to a 1-sec ITI from a 5-sec baseline resulted in very little change in accuracy.

Figures 3A and B show a repeated change to a 25-sec ITI from a 15-sec baseline. Bird 5 showed no change in per cent correct responding concurrent with the change to the 25-sec condition. A change to a 1-sec ITI from a 25-sec baseline again had little effect. Bird 17 showed only a slight increment in correct responding as the first change was made from the 15-sec to the 25-sec condition. The change back to a 15-sec baseline produced an initial decrease with a later increase to the 15-sec baseline performance. Only a temporary decrease in matching accuracy followed the change to a 1-sec ITI from a 25-sec ITI condition. Figure 3C shows the effect of repeated changes from 5-sec to 15-sec ITI for Bird 18. The effects were unreliable for this subject.

DISCUSSION

An ITI value above 0 sec appears to be necessary for stable acquisition and maintenance of hue matching above chance levels.

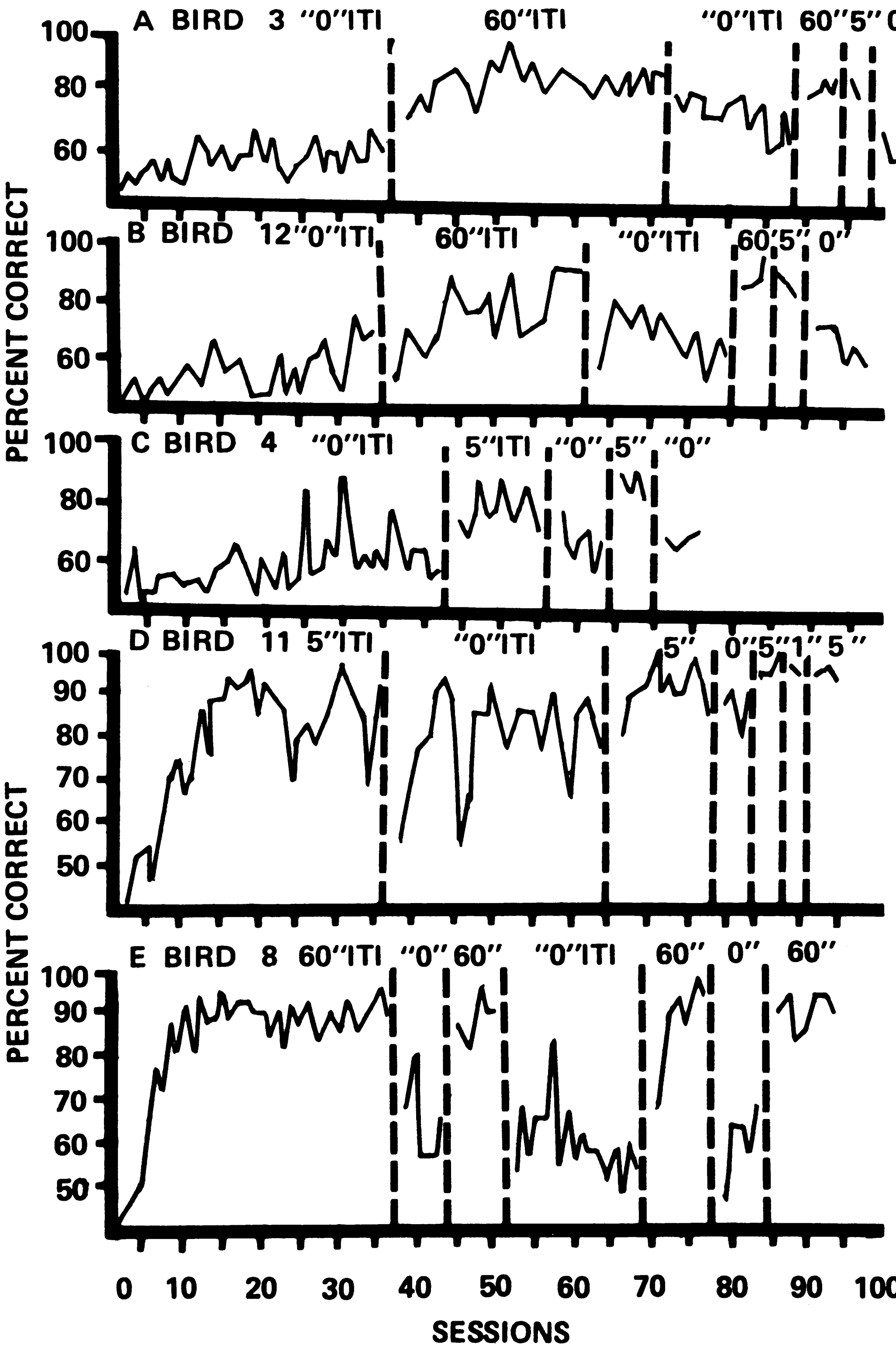

Fig. 2. Matching-to-sample performance as a function of repeated intertrial interval (ITI) changes.

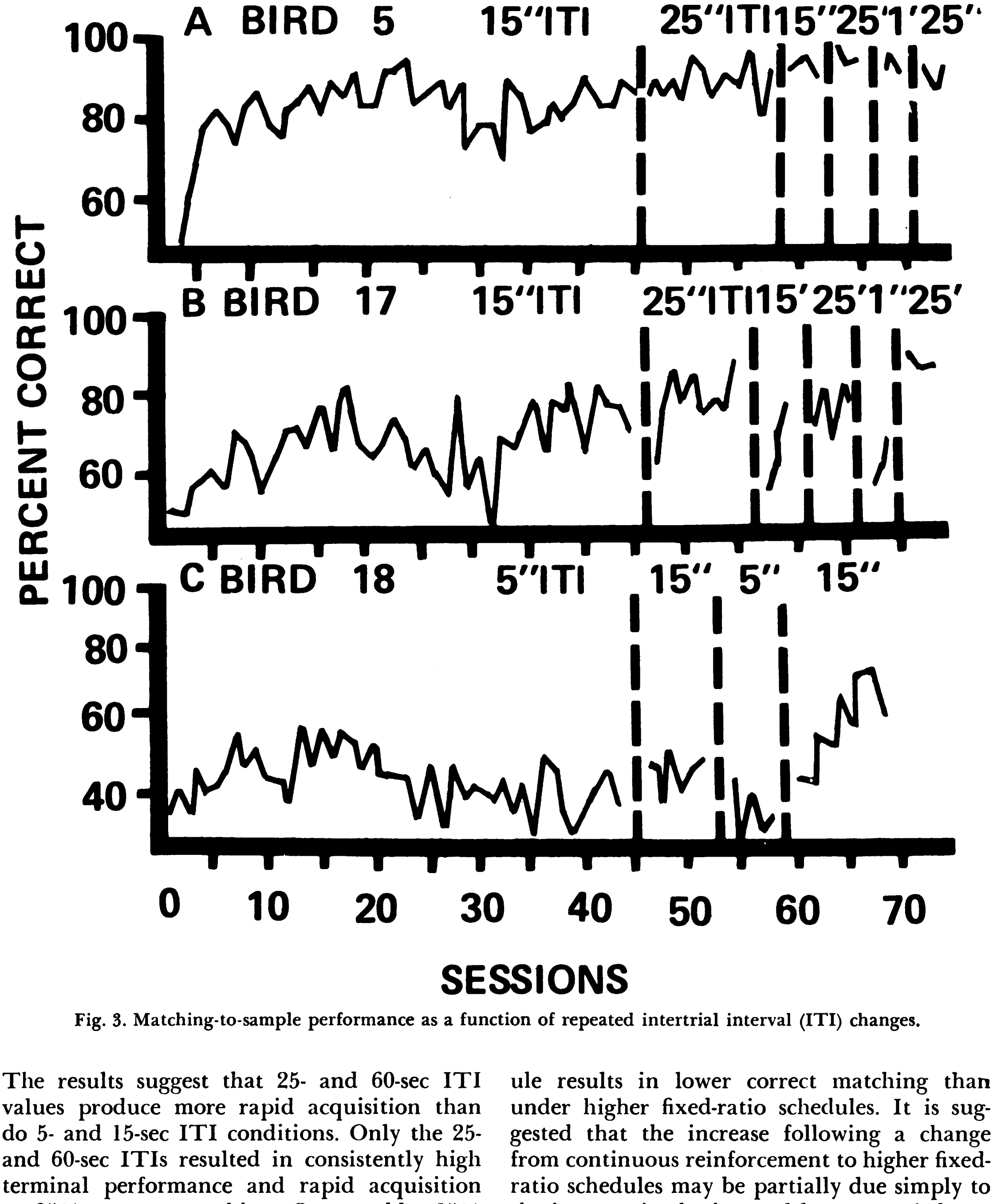

Fig. 3. Matching-to-sample performance as a function of repeated intertrial interval (ITI) changes.

The results suggest that 25- and 60-sec ITI values produce more rapid acquisition than do 5- and 15-sec ITI conditions. Only the 25- and 60-sec ITIs resulted in consistently high terminal performance and rapid acquisition to 85% correct matching. Once stable, 85% correct matching had been acquired, an ITI value as low as 1 sec was sufficient to maintain accurate performance. Upward changes in ITI values from 5 to 15 sec and 15 to 25 sec had little reliable effect upon hue matching.

Ferster (1960) found that without the use of an ITI, a continuous reinforcement schedule results in lower correct matching than under higher fixed-ratio schedules. It is suggested that the increase following a change from continuous reinforcement to higher fixed-ratio schedules may be partially due simply to the increase in the interval between reinforcements. It is suggested that continuous reinforcement and higher fixed-ratio schedules should be examined independently with and without a 0-sec ITI.

With reinforcement occurring after every response or 0-sec ITI, pigeons make random center side-key matching responses. Under these conditions, where reinforcement frequency is high, the pigeon's head is oriented toward the grain magazine instead of toward the response keys, as it would be under high FR requirements or high ITIs. Thus, the pigeons attend less to correct center side-key matches. Informal observation in the present experiments revealed that with a 0-sec ITI, fewer head bobbing movements occurred than with longer ITIs. Their movements of the head from right to left after center-key responses may be interpreted as observing responses. Such responses have been found to increase matching accuracy (Eckerman, *et al.*, 1968).

Thus, conditions such as a 0-sec ITI or a continuous reinforcement schedule increase reinforcement frequency, decrease observing response frequency, and decrease matching accuracy.

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