

## Letter

### THE EFFECT OF INTERTRIAL INTERVAL FOOD PRESENTATIONS ON PIGEONS' DELAYED MATCHING TO SAMPLE ACCURACY<sup>1</sup>

Marcia L. Spetch

Department of Psychology, University of California, San Diego, La Jolla, California, USA 92093

Present Address. Department of Psychology, Dalhousie University, Halifax, Nova Scotia, CANADA B3H 4J1

(Accepted 23 August 1984)

#### ABSTRACT

Spetch, M L., 1985 The effect of intertrial interval food presentations on pigeons' delayed matching to sample accuracy *Behav Processes* 11 309-315

Parallel effects of temporal variables on autoshaping and on delayed matching to sample performance suggest that delayed matching, like autoshaping, might depend upon the within-trial expectancy of reinforcement relative to the overall expectancy of reinforcement in the session. This possibility was assessed by presenting free food at different times during a 30-sec intertrial interval (ITI) in a delayed matching to sample procedure with pigeons. In three conditions a single free food presentation occurred, either early, mid-way, or late in each ITI, in another condition, three food presentations occurred during each ITI, one at each time location. Relative to a baseline condition, in which free food never occurred during the ITI, only food presentations late in the ITI produced a significant disruption in accuracy, and this effect occurred only at the longest of three delays tested. Three free food presentations in each ITI disrupted accuracy only to the same degree as a single, late, ITI food presentation. Thus, accuracy was affected by the temporal location rather than the frequency of ITI food presentations. These effects appear to differ from those of ITI food presentations on autoshaping and do not seem to be understandable in terms of changes in the background expectancy of reinforcement. It was suggested instead that food presented late in the ITI might disrupt subsequent memory processes.

**Key Words** Animal memory, DMTS, Scalar expectancy theory; ITI food, Pigeons

----

<sup>1</sup>This research was supported by a Natural Sciences and Engineering Research Council of Canada Postdoctoral fellowship held by the author, and by NIMH Grant No. 20752 to the University of California, San Diego (Principal investigator, E. Fantino). The author is grateful to Dr. Fantino for the generous use of his research facilities. These data were presented at the Canadian Psychological Association meeting in Ottawa, June 1984.

TABLE 1

Average percent correct at each delay under each condition for individual pigeons.

Delay Condition*	0					5					10				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Pigeon 1	100	100	100	100	99	93	93	97	93	88	85	80	77	75	65
2	82	86	85	82	88	68	60	47	63	52	57	60	68	58	45
3	98	98	97	97	100	75	85	77	67	87	83	75	65	57	68
4	94	98	98	98	98	80	58	73	67	68	69	58	72	62	61
5	99	98	93	93	87	88	91	76	70	76	72	65	64	55	54
6	98	95	91	92	84	82	90	72	70	78	70	72	61	55	67
7	96	94	94	96	91	65	78	63	75	68	78	70	68	58	53

\* Condition 1 = None, 2 = Early; 3 = Middle, 4 = Late, 5 = All

These observations were confirmed with an analysis of variance, which revealed a significant main effect of condition [ $F(4,24) = 6.12, p < .002$ ] and of delay [ $F(2,12) = 75.57, p < .001$ ], as well as a significant condition by delay interaction [ $F(8,48) = 2.31, p < .05$ ]. Pairwise comparisons between the five conditions at each delay (Newman-Keuls,  $\alpha = .05$ ) indicated that none of the differences between the five conditions were significant at the 0-sec or the 5-sec delays. However, at the 10-sec delay, the LATE condition and the ALL condition both differed significantly from the NONE condition and the EARLY condition. No other differences between the five conditions were significant at this delay. Thus, significant decrements in memory performance were seen only in the two conditions that contained free food late in the ITI.

#### DISCUSSION

There are two noteworthy features of the present results. First, free food presentations did not produce a general disruption of performance at all delays; instead, the effect of free food presentations interacted with delay, only having significant effects at the longest delay. Second, the temporal location rather than the frequency of food presentations during the ITI seemed to be the more important determinant of whether free food had a disruptive effect on performance at the long delay. The importance of temporal location was indicated by the significantly greater effect of free food presented late in the ITI than free food presented early in the ITI, and by the rank order of performance at the long delay under the three conditions that contained a single free food presentation EARLY > MIDDLE > LATE. On the other hand, the relative unimportance of frequency of free food presentation was indicated by the finding that performance did not differ significantly between the ALL condition, which contained three free food presentations during the 30-sec ITI, and the LATE condition, which contained only one.

Recently, Wilkie (1984) tested the effect of ITI food presentations on

## INTRODUCTION

Recently, Roberts and Kraemer (1982) noted a number of parallels between the effect of temporal variables in autoshaping and in delayed matching to sample (DMTS). First, increases in the intertrial interval (ITI) facilitate both the acquisition of autoshaped key-pecking (e.g., Gibbon, Baldock, Locurto, Gold, & Terrace, 1977) and choice accuracy in DMTS (e.g., Grant, 1975). Second, autoshaping acquisition is retarded by increases in the trial duration (T), the time between CS onset and reinforcement (e.g., Gibbon et al., 1977), and DMTS accuracy is disrupted by increases in the delay (D), time between sample offset and opportunity to obtain reinforcement by making a correct choice (e.g., Roberts & Grant, 1976). Third, autoshaping acquisition appears to be determined by the ITI/T ratio (Gibbon et al., 1977) and DMTS accuracy appears to depend, within limits, upon the ITI/D ratio (Roberts and Kraemer, 1982, Wilkie, 1984). Finally, performance in both situations appears to be sensitive to the mean ITI duration rather than to local variations in ITI length (Gibbon et al., 1977; Roberts & Kraemer, 1982).

These similarities led Roberts and Kraemer (1982) to suggest that some common processes may be involved in autoshaping and delayed matching. In particular, they proposed that the principles of scalar expectancy theory (Gibbon, 1977), which have been applied with considerable success to autoshaping (Gibbon & Balsam, 1981) might also have some applicability to delayed matching. In general terms, scalar expectancy theory proposes that autoshaping performance is determined by the expectancy of reinforcement within a trial relative to the overall expectancy of reinforcement within the session. Thus, shorter trial durations are thought to improve acquisition by increasing the within-trial reinforcement expectancy relative to the overall expectancy of reinforcement, and longer ITIs would improve acquisition by degrading the overall expectancy of reinforcement. Roberts and Kraemer (1982) suggested that DMTS accuracy might also be affected by the relative strength of within-trial reinforcement expectancies, and that some of the effects of ITI and D length in DMTS might be understood in terms of changes in the within-trial and the overall expectancy of reinforcement.

The purpose of the present study was to extend the work relating autoshaping and DMTS performance by examining the effect of free food given during the ITI on DMTS accuracy. Food presented during the ITI has been shown to disrupt autoshaping in a way that is generally consistent with scalar expectancy theory and similar theories, such as the relative waiting time hypothesis (Jenkins, Barnes, & Barrera, 1981). According to these views, free food disrupts performance by increasing the overall expectancy of food relative to the within-trial expectancy of food. Consistent with these views, autoshaping is affected more by the overall frequency of free food presentation than by the temporal location of free food within the ITI (Jenkins et al., 1981). If common processes underly autoshaping and DMTS performance, then ITI food presentations might have similar effects on DMTS accuracy.

## METHODS

### Subjects

The subjects were seven, adult, White Carneau pigeons maintained at 85% of their free-feeding weights. Each pigeon had been trained previously on the DMTS task. The pigeons were housed individually with water and health grit freely available

### Apparatus

Four pigeons were tested in cylindrical operant conditioning chambers (36 cm in height and 33 cm in diameter) and three were tested in 35.5 cm cubical chambers. All of the chambers contained three horizontally-aligned translucent response keys, which required a force of .13N to operate. Stimulus projectors mounted behind each key were used to transilluminate the keys with either white, green, or red light. A solenoid-operated grain hopper was located below the center key, a lamp within the hopper was illuminated during grain presentations. Experimental contingencies and data recording were controlled by a PDP-8E computer located in an adjacent room.

### Procedure

Since all pigeons had been previously trained on the DMTS task, no preliminary training was necessary. The basic DMTS task used consisted of 48 trials per session, with a 30 sec ITI between each trial. The trials began with illumination of the center key with white light (a trial initiating stimulus). A single peck to this initiating stimulus immediately changed the white light to either red or green light (the sample stimuli). The sample terminated after 5 sec independently of responses and was followed after a variable delay by illumination of the side keys, one with red and one with green light (the comparison stimuli). The right-left location of the two comparison stimuli was counterbalanced across trials. A peck to the comparison that matched the preceding sample was reinforced with 4-sec access to grain, a peck to the non-matching comparison resulted in termination of the trial. Within each session, 50% of the trials contained a 0-sec delay between the sample and the comparison stimuli, 25% of the trials contained a 5-sec delay, and 25% contained a 10-sec delay in a randomly determined order.

Each pigeon was tested under five conditions that varied with respect to the occurrence of free food presentations (4-sec access to grain). Condition 1 (NONE) was the baseline procedure in which free food was never presented during the 30-sec ITI. In Condition 2 (EARLY), a free food presentation occurred 5 sec after the beginning of each ITI of the session. In Condition 3 (MIDDLE), a free food presentation occurred 15 sec after the beginning of each ITI, and in Condition 4 (LATE), a free food was presented 25 sec after the beginning of each ITI. Finally, in the fifth condition (ALL), three free food presentations occurred, one at 5 sec, one at 15 sec, and one at 25 secs after the beginning of each ITI. The pigeons were exposed to the five conditions in a random order across 25 sessions, within the constraint that each condition occurred for a total of five sessions each. The order of testing varied between subjects

## RESULTS

The mean percent correct under each of the five conditions is shown as a function of delay in Figure 1. Table 1 shows the individual subject data. Each data point represents the average of the five test sessions at each condition. As can be seen, there was little difference in accuracy between the five conditions at the 0-sec delay, but as the delay increased, a detrimental effect of free food presentations on DMTS accuracy began to appear. This effect seemed to be due to temporal location rather than to the amount of free food. Free food presented late in the ITI produced a larger disruption in DMTS accuracy than free food presented early in the ITI, and there was very little difference between the "ALL" condition, in which three free food presentations occurred, and the "LATE" condition, in which only one free food was presented late in the ITI.

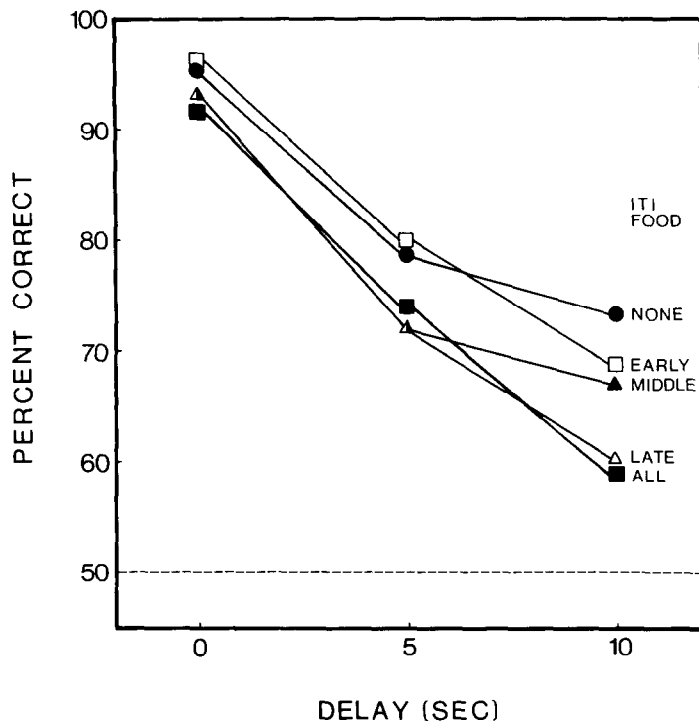


Fig. 1 Mean percent correct of the seven pigeons under each of the five conditions as a function of delay.

pigeons' delayed spatial matching and found a large disruptive effect on accuracy. In contrast to the present results, Wilkie found that accuracy was disrupted more by two reinforcement presentations than by a single one. However, this result is not necessarily inconsistent with the present findings because in his study the second of the two reinforcement presentations occurred a few sec later in the ITI than did the singly-presented reinforcement. Thus, it is possible that the greater disruption produced by two reinforcement presentations reflected the difference in temporal location rather than frequency of ITI food.

The effects of ITI food presentations on DMTS performance seen in the present study do not appear to resemble the effects of ITI food presentations on autoshaping. Although ITI food presentations produce some disruption of performance in both situations, the nature of this effect may be quite different in the DMTS task. Whereas autoshaping seems to be affected by the frequency rather than the temporal location of ITI food presentations (Jenkins et al., 1981), the present results suggest that the opposite may be the case for DMTS performance. Thus, the similarity between the effect of temporal variables on autoshaping and DMTS performance (Roberts & Kraemer, 1982) does not appear to extend to the effect of ITI food presentations.

The specific nature of the free food effects seen in the present study is unclear and must await the results of future studies. However, two interpretations of the results seem unlikely at this time. The first is that free food disrupts accuracy solely by increasing the background expectancy of food and thereby decreasing the relative within-trial food expectancy (cf. Gibbons, 1977). This seems unlikely given that performance was not sensitive to the frequency of ITI food presentations. The effect of temporal location but not frequency of free food presentations also appears to rule out satiation as an interpretation of the free food effect. Although temporary satiation for a few seconds following each free food presentation cannot be totally ruled out, two features of the present study make this interpretation unlikely. First, trials did not begin until the subjects initiated them, and second, performance was affected only at the longer delays, which were more remote in time from the free food presentation.

It seems more likely, on the basis of the interaction of free food with delay, that free food presentations might produce their effect by interfering with "memory" of the sample stimulus. There are several ways that this could occur. For example, a stimulus trace or memory of the free food might compete or interfere with the memory trace of the sample (Roberts & Grant, 1976). Alternatively, unexpected free food presentations might command rehearsal for a period of time, and thereby disrupt the rehearsal of the sample (Wilkie, 1984). Or perhaps free food presentations late in the ITI alter behaviors that normally occur during the delay and that form part of the controlling stimulus (cf. Blough, 1959) or context (cf. Kendrick & Rilling, 1981) for "remembering".

Research is currently underway to determine whether free food produces local, within-session effects on DMTS accuracy, whether signalling the free food alters its disruptive effect (cf. Wilkie, 1984), and whether performance is also affected by the presentation of a different type of reinforcer during the ITI. The outcome of these studies should help to clarify the nature of the effects of free food presentations on DMTS performance.

## REFERENCES

- Blough, D.S., 1959. Delayed matching in the pigeon. *J. Exp. Anal. Behav.* 2: 151-160.
- Gibbon, J., 1977. Scalar expectancy theory and Weber's law in animal timing. *Psychol. Rev.* 84: 279-325.
- Gibbon, J., Baldock, M.D., Locurto, C.M., Gold, L., and Terrace, H.S., 1977. Trial and intertrial durations in autoshaping. *J. Exp. Psychol. Anim. Behav. Proc.* 3: 264-284.
- Gibbon, J., and Balsam, P., 1981. Spreading association in time. In H.S. Terrace and J. Gibbon (Editors), *Autoshaping and Conditioning Theory*. Academic Press, New York.
- Grant, D.S., 1975. Proactive interference in pigeon short-term memory. *J. Exp. Psychol. Anim. Behav. Proc.* 1: 207-220.
- Jenkins, H.M., Barnes, R.A., and Barrera, F.J., 1981. Why autoshaping depends on trial spacing. In L.C. Locurto, H.S. Terrace, and J. Gibbons (Editors), *Autoshaping and Conditioning Theory*. Academic Press, New York.
- Kendrick, D.F., Rilling, M., and Stonebraker, T.B. Stimulus control of delayed matching in pigeons. Directed forgetting. *J. Exp. Anal. Behav.* 36: 241-251.
- Roberts, W.A., and Grant, D.S., 1976. Studies of short-term memory in the pigeon using the delayed matching-to-sample procedure. In D.L. Medin, W.A. Roberts, and R.T. Davis (Editors), *Processes of Animal Memory*. Erlbaum, Hillsdale, N.J.
- Roberts, W.A., and Kraemer, P.J., 1982. Some observations of the effects of intertrial interval and delay on delayed matching to sample in pigeons. *J. Exp. Psychol. Anim. Behav. Proc.* 8: 342-353.
- Wilkie, D.M., 1984. Pigeons' spatial memory IV. Effects of intertrial interval manipulations on delayed matching of key locations. *Can. J. Psychol.* 38: 178-195.