Trace Autoshaping in Pigeons : Acquisition and Maintenance at Short Trace Intervals

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TRACE AUTOSHAPING IN PIGEONS: ACQUISITION AND MAINTENANCE AT SHORT TRACE INTERVALS

Tsuneo Kito

Summary.——Three groups of pigeons were trained to examine the acquisition and maintenance of signal-directed key pecking under a trace conditioning procedure containing relatively short trace intervals. The 18 subjects were randomly assigned to three trace autoshaping conditions which contained a 2-sec, 4-sec, or 8-sec trace interval. All the six pigeons in the 2-sec trace group and five of the six pigeons in the 4-sec trace group acquired and maintained the key pecking. In the 8-sec trace group, three of the six pigeons failed to develop the responding under the trace conditioning procedure. The percentage of CS trials with a key peck response was a decreasing function of the trace interval. A Kruskal-Wallis H test indicated a significant effect of trace interval. Subsequent Mann-Whitney U tests revealed reliable differences in the percentage of CS trials with a response between the 2-sec trace group and the other two groups. There were no differences between the 4-sec trace group and 8-sec trace group.

Key words: autoshaping, trace conditioning, short trace interval, distribution of response, key pecking, pigeons

Introduction

Brown and Jenkins (1968) reported that pigeons acquired a key pecking response when 8-sec illuminations of a response key precede each presentation of grain, even though the food presentation was independent of the pigeon's behavior. Brown and Jenkins called this procedure autoshaping, because it was automatic, the pigeon shaped itself. The phenomenon of autoshaping has raised theoretical issues which go to heart of the experimental analysis of behavior because key pecking in pigeon has been considered a prototypic operant behavior (Schwartz & Gamzu, 1977).

The phenomenon of autoshaping is often regarded as an example of Pavlovian conditioning in which a food delivery as an US is signaled by a key light as a CS (Jenkins & Moore, 1973; Mackintosh, 1974; Hearst & Jenkins, 1974; Schwartz & Gamzu, 1977). With regard to the temporal arrangement of stimulus events, the standard autoshaping procedure is a delay conditioning procedure in Pavlovian paradigm. It seems the procedure is an optimum procedure to make the CS-CR association.

Many studies on autoshaping have been done. However, a different kind of procedure other than delay conditioning were used in a few studies. For example, Gamzu and Williams's differential-absence procedure seems a variety of trace conditioning. Gamzu and Williams (1973) reported that the pigeon's key pecking was not acquired under this condition. That is to say, the difficulty in acquisition of the autoshaped key pecking under trace conditioning was shown. The procedure used in Gamzu and Williams (1973) was, however, an occasional trace conditioning in which a variable trace interval occurred. As the result, the birds failed to acquire the autoshaped key pecking under the procedure.

Newlin and LoLordo (1976) explored a variety of classical procedures within the autoshaping paradigm. In their study, Newlin and LoLordo compared pigeon's autoshaping performance under serial, delay, and trace conditioning procedures. With respect to the trace procedure, they reported robust responding to a 4-sec keylight CS that was separated from food US by a 4-sec trace interval. However, relatively little activity was directed to the CS in a group trained with a 28-sec trace interval. On the other hand, Lucas, Deich, and Wasserman (1981) examined whether autoshaped behavior would be acquired and maintained at relatively long trace interval (Exp. 1). Their results indicated that the majority of subjects acquired signal-directed key pecking with trace intervals as long as 36 sec, and that the percentage of CS trials with a response was a decreasing function of the trace interval.

The aim of the present study was to investigate the acquisition and maintenance of pigeon's autoshaped key pecking under a trace conditioning procedure. The present study sought to provide a detailed data using relatively short trace intervals. So, the three values of the trace interval, 2-sec, 4-sec, and 8-sec, were used.

Method

Subjects

Eighteen experimentally naive pigeons (*Columba livia*) were maintained at approximately 80% of their free-feeding weights. All were individually housed in a separated colony room with continuous access to water. Subjects were given a daily grit immediately following daily experimental sessions.

Apparatus

Single key conditioning chamber was used (see Figure 1). The interior dimensions of the experimental space were 32 cm long by 33 cm wide by 37 cm high. The feeder aperture was 5 cm wide by 5 cm high and was centered on the front panel 4 cm above the wire mesh floor. The response key (response aperture) was 3 cm in diameter and located on the front panel. The distance from center of the key to center of the food aperture was 13.5 cm. Stimulus was presented through the transparent Plexiglas surface of the response key lighted by three light-emitting diodes. The response was detected by a photo interrupter located behind the response key. During food tray presentation, the aperture was illuminated from within by a pair of magazine lights. The houselight was centered on the ceiling. Scheduling, data recording and data analysis were managed by a SHARP MZ-80 microcomputer and some peripheral equipments involving handmanufactured I/O interface (see Matsuo, Kito & Ohtsubo, 1983). The conditioning chamber was housed in wooden box. Fresh air and masking noise were provided by a ventilation fan located one side wall of the box.

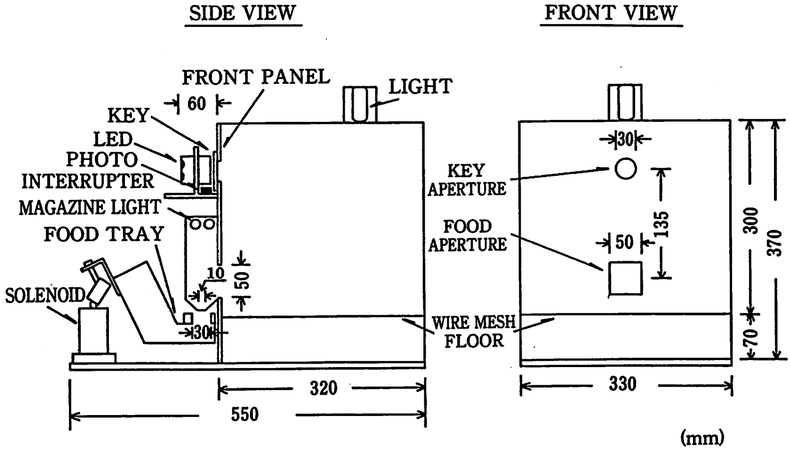

Figure 1. The conditioning chamber used in this study.

Procedure

Each subject was exposed to the experimental chamber and trained to eat readily when the food tray was presented (magazine training). On the day immediately after the pigeon accomplished given criterion of the magazine training, then the bird did trace autoshaping sessions. The procedures of magazine training and trace autoshaping were as follows.

Magazine training. Before trace autoshaping sessions, subjects recieved the magazine training consisting of two phases. In both the phases, each subject recieved repeated food presentations independently of the bird's behavior. Intervals of the food presentation were 10-sec in the first phase, and 4-sec in the second phase. In both the phases, the food presentation was repeated 28 times in a session, and performed one session per day. The interstimulus intervals varied randomly from 30 to 90 sec in 10-sec steps. All values were equally represented, yielding a mean duration of 60 sec. The criteria of the training were that the subject must eat the food more than 14 times (first phase) or more than 23 times (second phase) of 28 food presentations. On the day immediately after the subject accomplished given criterion of the first phase, then the subject was shifted to the second phase. In practice, this preliminary procedure resulted in 2 to 7 days to complete the magazine training.

Trace autoshaping. The conditioned stimulus (CS) for each subject was a 8-sec illumination of the response key with yellow light. Each trial consisted of the presentation of CS, followed by a trace interval (TI) in which stimulus conditions were identical to those present between trials, followed by the unconditioned stimulus (US), a 4-sec presentation of the food tray. The three values used for the TI were 2, 4,

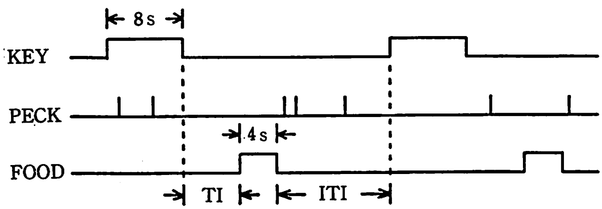

Figure 2. Schematic representation of the procedure.

and 8 sec. Schematic representation of the procedure was shown in Figure 2. The TI was timed from the offset of the keylight to the onset of the food tray. A variable intertrial interval (ITI) was scheduled between the offset of the food tray and the onset of the next CS. The ITI was identical to the interstimulus interval in the magazine training. The key pecking had absolutely no effect on the experimental procedure. The houselight was continuously illuminated. The daily session consisted of 35 trials. Experimental training in this phase lasted for 11 sessions.

The 18 subjects were randomly assigned to 3 groups (n = 6). Except for the duration of the trace interval, experimental training was identical for all subjects.

Following the trace autoshaping phase, the subjects failed to develop the key pecking were transferred to a 0-sec trace condition (i. e., a simple Pavlovian delay conditioning procedure) to assess an acquisition of the signal-directed key pecking under the standard autoshaping procedure. Except for the duration of the trace interval, all other conditioning parameters were identical to those used in the prior trace autoshaping procedure. This procedure remained in effect for 7 sessions.

Results

Figures 3, 4, and 5 show the percentage of CS trials at least with a key peck response for each subject under 2-sec, 4-sec, and 8-sec trace interval condition, respectively.

For the 2-sec trace group, all six birds acquired and maintained autoshaped key pecking. Most subjects of this group occurred first response in the first or second session. The bird #15 began some key pecks during the magazine training, so it's first autoshaped key pecking occurred at the initial trial in the first session. All birds of this group established stable maintenance of responding within the six sessions (see Figure 3). For the 4-sec trace group, five of the six birds acquired the key pecking. Direct observation showed that the first response of the birds in this group occurred later than that of 2-sec group

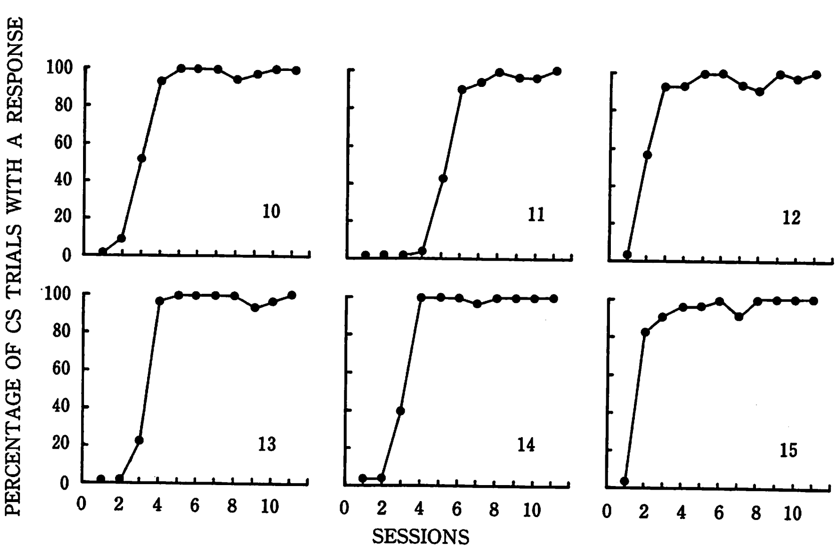

Figure 3. The percentage of CS trials with a response for each subject in the 2-sec trace group.

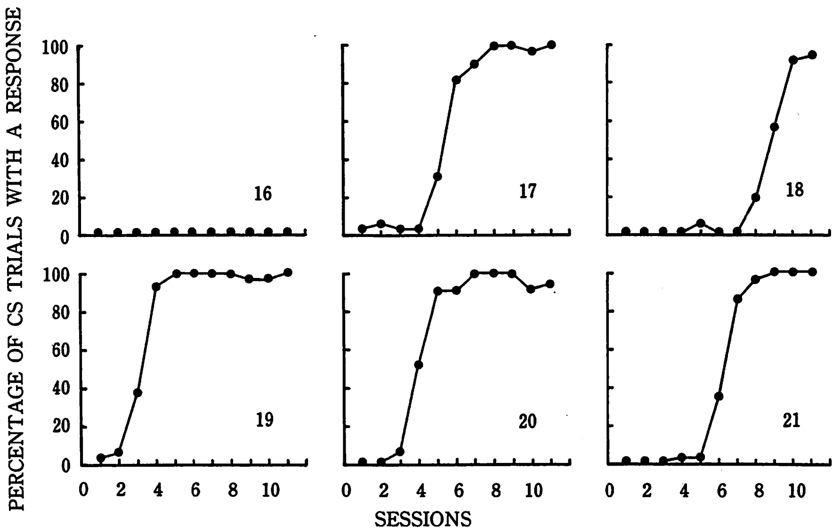

Figure 4. The percentage of CS trials with a response for each subject in the 4-sec trace group.

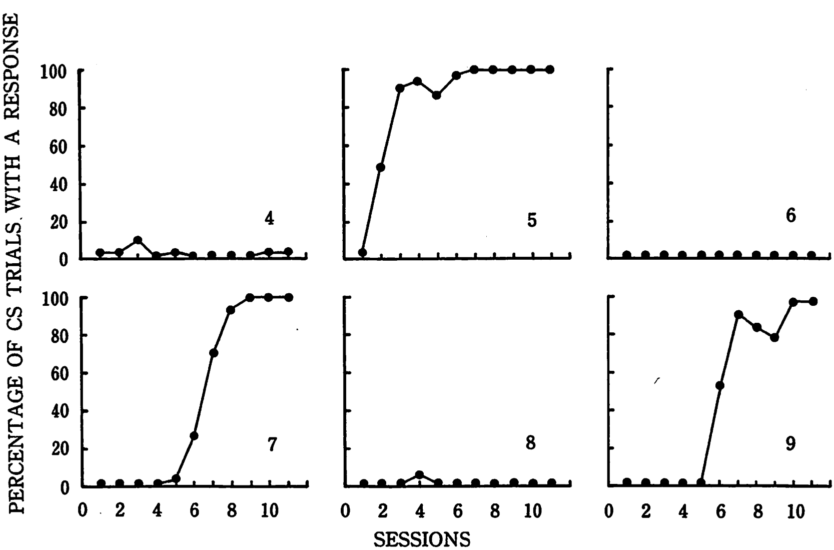

Figure 5. The percentage of CS trials with a response for each subject in the 8-sec trace group.

(see Figures 3 and 4). Only one bird #16 failed to acquire the key pecking. For the 8-sec trace group, three of the six birds failed to develop the key pecking within the 11 sessions (see Figure 5).

In general, overall responding was an inverse function of the trace interval. Figure 6 shows group means and standard deviations for the percentage of CS trials with a key peck response across 11 sessions. Direct osbervation showed that the percentage of CS trials with a response decreased monotonically as the trace interval increased. A Kruskal-Wallis H test by ranks indicated a significant effect of trace interval, $H(2)=8.626$, $p<.05$. Subsequent Mann-Whitney U tests revealed reliable differences in the percentage of CS trials with a response between the 2-sec trace group and the other two groups (2-sec vs. 4-sec and 2-sec vs. 8-sec: $U(6,6)=1$, $p<.01$, $U(6,6)=4$, $p<.05$, respectively). There are no differences between the 4-sec trace group and the 8-sec trace group, $U(6,6)=12.5$, $p>.05$.

Table 1 shows summary measures for each subject across the 11

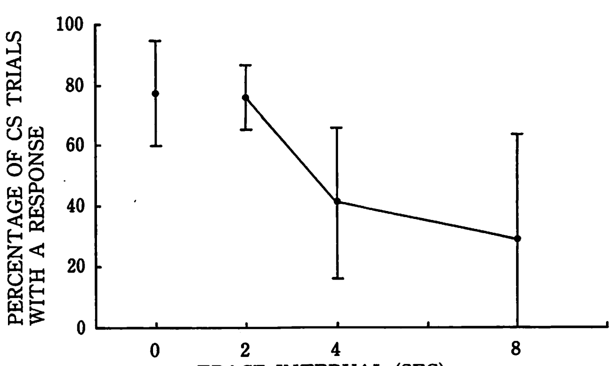

Figure 6. The group means and standard deviations for the overall percentage of CS trials with a response as a function of the trace interval ($n=6$). Added data at 0-sec was yielded in Kito's prior study (1987, Exp. 1) in which the experimental condition was identical to the present study except for the trace interval.

Table 1. The percentage of the CS trials, TI, and ITI with a response. Data were means on performance across all 385 trials.

2-sec trace interval				4-sec trace interval				8-sec trace interval			
Ss	CS trial	TI	ITI	Ss	CS trial	TI	ITI	Ss	CS trial	TI	ITI
10	76.9	10.4	62.3	16	0.0	0.3	0.0	4	12.3	0.0	0.8
11	56.9	2.6	19.5	17	56.1	10.6	28.3	5	83.6	9.9	54.0
12	84.7	2.3	13.0	18	24.4	0.3	14.0	6	0.0	0.0	0.0
13	73.8	73.0	30.1	19	55.6	10.4	25.4	7	44.4	2.6	16.1
14	76.6	9.9	58.4	20	66.2	2.6	13.0	8	0.5	1.6	8.3
15	87.5	9.1	63.1	21	47.5	13.8	27.2	9	45.2	1.8	14.8
Mean	76.1	17.9	41.1	Mean	41.6	6.3	18.0	Mean	29.3	2.7	15.7
SD	10.8	27.2	22.8	*SD*	24.8	5.6	11.0	*SD*	34.2	3.7	20.0

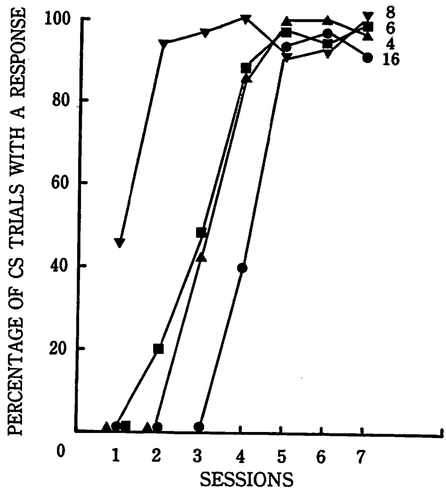

Figure 7. The percentage of CS trials with a response under the 0-sec trace condition.

sessions. The data in Table 1 indicates that the percentage of CS trials with a response is higher than those of the trace interval and the intertrial interval period. Seeing Table 1, you should notice that the length of duration of the CS trial (8 sec) was shorter than that of the mean intetrial interval (60 sec).

Finally, all subjects failed to develop the key pecking under the present trace conditions acquired and maintained substantial autoshaped key pecking under the 0-sec trace condition (delay conditioning procedure or autoshaping procedure). The results were shown in Figure 7. Direct observation showed that the four birds established stable maintenance of the responding at least within five sessions.

Discussion

As the results of Newlin and LoLordo (1976) and Lucas *et al.* (1981), the present results showed that autoshaped key pecking was inversely related to the trace interval. However, the percentage of CS trials with a response in this study was lower than that of Lucas *et al.* (1981). This result can be explained in terms of the ratio of the CS trial duration and the intertrial interval duration. Gibbon, Baldock, Locurto, Gold, and Terrace (1977) and Terrace, Gibbon, Farrell, and Baldock (1975) showed that lengthening the duration of the intertrial interval relative to the duration of the CS facilitated the acquisition of autoshaped key pecking. According to these findings, it is shown that the rate of acquisition in this study is slower than that of Lucas *et al.* (1981).

My finding is that the performance of birds under the 2-sec trace condition differ from those of the 4-sec condition and the 8-sec trace condition. Rather, the performance under the 2-sec trace interval condition is similar to that of standard autoshaping (0-sec trace) condition (see Figure 6). A Mann-Whitney U test indicated that the percentage of CS trials with a response in the 2-sec trace group did not differ significantly from that of the 0-sec trace group, $U\ (6,7)=18,\ p>.05$.

The literature on Pavlovian conditioning often reported that most

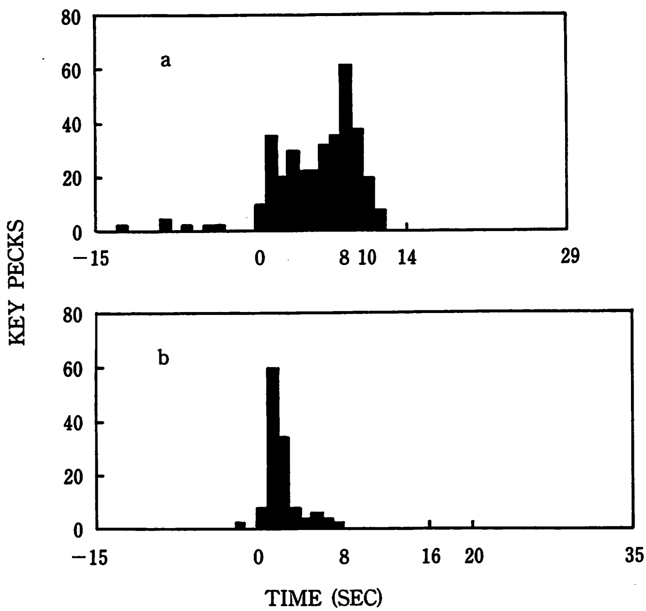

Figure 8. Examples of the distribution of key pecks: (a) an exceptional pattern and (b) a typical pattern. Data are based on performance in the 11th session. The CS were presented at 0 sec. The trace intervals were from 8 sec to 10 sec for the 2-sec trace group and from 8 sec to 16 sec for the 8-sec trace group.

of the conditioned responding were elicited during the trace period (*e. g.*, Pavlov, 1927; Rescorla, 1968) . Whereas, Newlin and LoLordo (1977) and Lucas *et al.* (1981) found that more key pecks were emitted during the CS period than during the trace interval period. In addition, Wasserman (1973) and Kito (1987) showed that most key pecking under an autoshaping procedure occurred shortly after the CS onset. Generally, the present results are consistent with Newlin and LoLordo's and Lucas, Deich, and Wasserman's observations. With respect to the temporal distribution of key pecks, most birds except only one bird # 13 in the 2-sec trace group showed similar tendency. Bird #13 emitted a number key peckings which occurred during the trace interval period. The key pecking at the start of the trace interval may have resulted from carryover CS-directed pecks occurring at the end of the CS period. Figure 8 shows an exceptional pattern (a: bird #13, 2-sec group) and a typical pattern (bird #9, 8-sec group) of the temporal distribution of key pecks in the 11th session. This figure also shows that most key pecks occurred during the CS period. Further, the peak of responding was found shortly after the CS onset.

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