THE ROLE OF AUTOPECKING IN BEHAVIORAL CONTRAST¹

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Four groups of four pigeons each were studied on two different multiple schedules. The cues correlated with the schedule components were localized on the response key for two groups and were not localized for the others. Two groups worked on multiple schedules with variable interval 15-sec in both components, and variable interval 15-sec in one component and extinction in the other. The other two groups had identical procedures except that food was presented on a response-independent variable-time schedule. Variable-interval birds with localized stimuli showed marked behavioral contrast; variable-interval birds with non-localized stimuli showed no behavioral contrast. Variable-time birds with key-light stimuli acquired high rates of autopecking, which changed as treatment changed in a manner that paralleled rate changes, resulting in behavioral contrast for variable-interval birds. Variable-time birds with non-localized stimuli key pecked only at a low rate. The findings indicate that behavioral contrast in pigeons may result from the autopecking that is obtained with stimulus-contingent food presentation.

Gamzu and Schwartz (1973) obtained considerable key pecking in pigeons by presenting stimulus-contingent response-independent food on a variable-time (VT) schedule. They employed multiple schedules (*mult*), compound schedules in which two or more successive component schedules are associated with different stimuli. In some of their multiple schedules, the two component schedules were the same and in others they were not. When the component schedules differed, *e.g.*, when one component was VT 33-sec and the other was extinction (EXT), considerable key pecking was obtained to the positive stimulus. When the component schedules were both the same (*e.g.*, *mult* VT 33-sec VT 33-sec), key pecking declined. This effect of response-independent food presentation is closely akin to autoshaping, the key pecking Brown and Jenkins (1968) obtained when a stimulus was presented on the key for a few seconds before

response-independent food presentations. Williams and Williams (1969) showed that such autopecking will occur even when it prevents food presentation, indicating that autopecking does not result from accidental response-food contingencies.

The present experiment was designed to determine more about how behavioral contrast is affected by autopecking tendencies that result from contingencies between stimuli and food presentation. Behavioral contrast is typically obtained when subjects are trained on one multiple schedule and then shifted to another in which the second component is altered while the first is not. Contrast is said to occur if rate of responding in the first component changes in the opposite direction from rate in the second component. For example, if when a multiple schedule with identical variable-interval components (*mult* VI 60-sec VI 60-sec) is changed to *mult* VI 60-sec EXT, rate of responding decreases in the second (EXT) component and increases in the first component; this latter change is a case of (positive) behavioral contrast.

It is noteworthy that the most striking examples of contrast have been obtained with pigeons when the stimuli associated with the component schedules are located on the response key (Rachlin, 1973). The most marked contrast is found under conditions quite simi-

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lar to those in which autopecking is obtained. Thus, contrast may result at least in part from the same response-independent effects that lead to autopecking.

We reasoned that since there is marked autopecking only when the stimulus is located on the response key (Wasserman, 1973) contrast should be greater and possibly occur in key pecking by pigeons only when the stimuli are on the key. Two groups of birds were studied on both *mult VI EXT* and *mult VI VI* schedules. For one group, the stimuli associated with the schedule components were on the response key; for the other group, the stimuli associated with the component schedules were not localized. In the latter instance, the houselight was used. Other birds were yoked to each subject in these groups. That is, there were two groups receiving comparable *mult VT EXT* and *mult VT VT* schedules with components marked by non-localized stimuli or stimuli on the response key. These groups provided measures of the separate effects of autopecking tendencies.

METHOD

Subjects

Sixteen White King pigeons, obtained from a local supplier, were maintained at 75% (± 10 g) of free-feeding weight and housed in individual cages in a colony room kept under constant illumination.

Apparatus

Two identical experimental chambers, 33 by 39 by 31 cm, were equipped with a translucent response key (Gerbrands) located 22 cm from the floor and in the center of one side directly above the opening providing access to the grain feeder (Lehigh Valley). The key was transilluminated by either a white, green, blue, or red light. Transillumination was accomplished by miniature lamps mounted behind the response key. The houselights were white, green, blue, and red General Electric Christmas tree lamps located behind a round (5.9 cm diameter) translucent plastic window in the center of the ceiling of the experimental chamber. Each key peck produced auditory feedback by operating a relay mounted behind the response-key panel.

A masking noise, about 90 dB inside the experimental chamber (on the A scale of Gen-

eral Radio Company sound level meter) was provided by a ventilating fan and white noise. Experimental events were controlled by standard relay equipment and recorded on counters, print-out counters, and cumulative recorders. Inspection of records and observation of subjects provided no evidence that sounds from the equipment when reinforcement was scheduled affected the bird's behavior.

Procedure

All birds were habituated to eat freely from the feeder when it was presented. During this habituation, the key was covered with tape and the chamber was illuminated by the white houselight.

After feeder habituation, subjects were randomly assigned to VI and VT pairs. For the remainder of the experiment, each VT bird was yoked to a VI bird, *i.e.*, the VT bird received the same sequence of stimulus presentations (both lights and food) as the VI bird with which it was yoked. Key pecking by the VI birds on the white key was hand-shaped during white houselight illumination. There were four sessions under these stimulus conditions during which a total of 120 pecks were reinforced by 2.5-sec food presentations. The last 50 of these food presentations were earned on a VI 15-sec schedule. It will be remembered that the VT birds were yoked to their VI partner for all sessions following habituation to the feeder.

Before Phase I of the main experiment was initiated, pairs of birds were randomly assigned to houselight or keylight conditions, making a total of four groups: K-VI, K-VT, H-VI, H-VT. The designations indicate the location of the stimuli on the key (K) or houselight (H) and VI and VT indicate whether food presentations were response-dependent (VI) or independent of that bird's behavior (VT). The houselight was white throughout for Group K-VI and K-VT, and the key was white for the other two groups.

The procedure during Phases I to III is described only for VI birds. The procedure for the yoked birds is implied. The only difference between procedures for K-VI and H-VI birds was the location of the stimuli associated with the component schedules.

Each daily experimental session of Phase I consisted of 22 cycles of a two-component multiple schedule. The stimulus was red during

the first component, 20 sec of VI 15-sec. The stimulus during the second component, 4 min of extinction, was blue for half the birds in each group and green for the others. The two components alternated. There were 20 to 22 daily sessions during Phase I.

Phase II consisted of 10 sessions of *mult* VI 15-sec VI 15-sec. Each session was terminated after 40 food presentations. The first component was identical to the first component of Phase I. The stimulus during the second component was green or blue, whichever had not been used for that bird during Phase I. The alternating components were both 20 sec in duration.

Phase III lasted for 10 sessions the first of which was identical to a Phase I session. Sessions 2, 4, 6, 8, and 10 were identical to Phase II sessions. Sessions 3, 5, 7, and 9 were like those of Phase I except that the second (extinction) component lasted 20 sec rather than 4 min.

The major features of the procedure are summarized in Table 1. It is noteworthy that the schedule during red (first component) was VI 15-sec throughout.

RESULTS

The terminal rates of responding in pecks per minute for individual birds and group means during each component of Phase I and II and both multiple schedules of Phase III are presented in Table 2. Each entry represents a mean value for the last four days of that condition during that phase. Also presented are indices of differential rates (DR), which are $C/C + V$ where C represents rate in the red VI (or VT) 15-sec component and V represents rate in the variable component, which was VI (or VT) in some cases and EXT

in others. Exclusive responding in the constant component results in an index of 1.0, whereas equal response rates in the two components result in an index of 0.5.

Since interpretation of other measures depends on whether the VI groups responded differentially to the two components of the multiple schedules, the index of differential responding (DR) for these groups will be examined first. Figure 1 shows the mean DR for Groups K-VI and H-VI in each daily session (except the two extra sessions some birds received at the end of Phase I). At steady state during Phase I (*mult* VI 15-sec EXT), both VI groups made few pecks during the extinction component, i.e., the index was close to 1. It may be noted that acquisition of differential responding was more rapid for Key than Houselight birds. This difference is reliable

Fig. 1. Mean index of differential responding (rate of responding in responses per minute during the constant component divided by the sum of the rates during constant and variable components) for each VI group during Phases I to III. Schedules were *mult* VI 15-sec EXT, *mult* VI 15-sec VI 15-sec, and alternation of VI-EXT and VI-VI during Phases I, II, and III respectively. The VI-EXT and VI-VI days of Phase III are represented by separate curves.

Table 1
Summary of Procedure for VI Birds

Phase	Session	First Component			Second Component		
		Stimuli	Duration	Schedule	Stimuli	Duration	Schedule
I	1-20 (or 22)	red	20 sec	VI 15-sec	blue*	4 min	EXT
II	1-10	red	20 sec	VI 15-sec	green*	20 sec	VI 15-sec
III	1	red	20 sec	VI 15-sec	blue	4 min	EXT
	2, 4, 6, 8, and 10	red	20 sec	VI 15-sec	green	20 sec	VI 15-sec
	3, 5, 7, and 9	red	20 sec	VI 15-sec	blue	20 sec	EXT

*Blue and green were counterbalanced across subjects.

Table 2

Mean rate of responding and mean index of differential responding (DR) averaged over the last four days for individual subjects and group means.

Phase III													
Phase I				Phase II			VI-EXT			VI-VI			
Component				Component			Component			Component			
		1	2										
		VI											
		15-sec	EXT	DR	15-sec	15-sec	DR	15-sec	EXT	DR	15-sec	15-sec	DR
		VI			VI	VI		VI			VI	VI	
K-VI		15-sec	EXT	DR	15-sec	15-sec	DR	15-sec	EXT	DR	15-sec	15-sec	DR
1		74.32	2.74	0.96	25.95	31.39	0.45	56.22	20.74	0.73	36.90	41.75	0.47
2		84.32	0.68	0.99	65.75	53.92	0.55	109.46	21.05	0.84	50.97	55.35	0.48
3		60.72	0.11	1.00	52.74	48.06	0.52	65.35	4.10	0.94	51.76	59.83	0.46
4		99.02	0.45	1.00	47.28	100.74	0.32	102.16	4.44	0.96	57.62	74.84	0.44
M		79.60	1.00	0.98	47.93	58.53	0.46	83.30	12.58	0.87	49.31	57.94	0.46
		VT			VT			VT			VT		
		15-sec	EXT	DR	15-sec	15-sec	DR	15-sec	EXT	DR	15-sec	15-sec	DR
K-VT		15-sec	EXT	DR	15-sec	15-sec	DR	15-sec	EXT	DR	15-sec	15-sec	DR
1		59.80	0.10	1.00	8.36	0.67	0.93	23.24	0.11	1.00	5.51	0.05	0.99
2		105.46	0.06	1.00	6.76	0.16	0.98	88.66	0.44	1.00	9.23	0.72	0.93
3		9.76	0.07	0.99	0.52	1.06	0.33	2.29	0.08	0.97	0.61	0.10	0.86
4		28.73	0.12	1.00	6.81	0.58	0.92	52.07	0.20	1.00	11.30	0.56	0.95
M		50.94	0.09	1.00	5.61	0.62	0.79	41.56	0.21	0.99	6.66	0.36	0.93
		VI			VI			VI			VI		
		15-sec	EXT	DR	15-sec	15-sec	DR	15-sec	EXT	DR	15-sec	15-sec	DR
H-VI		15-sec	EXT	DR	15-sec	15-sec	DR	15-sec	EXT	DR	15-sec	15-sec	DR
A		84.97	1.11	0.99	57.77	64.34	0.47	63.94	69.74	0.48	67.24	73.86	0.48
B		27.76	0.47	0.98	50.56	42.49	0.54	51.02	40.16	0.56	54.47	41.10	0.57
C		31.03	0.32	0.99	47.05	38.98	0.55	55.40	30.31	0.65	53.56	30.36	0.64
D		34.92	1.72	0.95	22.74	17.36	0.57	37.68	32.81	0.53	40.16	29.68	0.58
M		44.67	0.90	0.98	44.53	40.79	0.53	52.01	43.25	0.56	53.86	43.75	0.57
		VT			VT			VI			VT		
		15-sec	EXT	DR	15-sec	15-sec	DR	15-sec	EXT	DR	15-sec	15-sec	DR
H-VT		15-sec	EXT	DR	15-sec	15-sec	DR	15-sec	EXT	DR	15-sec	15-sec	DR
A		1.93	0.01	0.99	0.30	0.14	0.68	0.14	0.04	0.78	0.22	0.37	0.37
B		10.42	0.03	1.00	0.21	0.05	0.81	0.34	0.04	0.89	0.10	0.00	1.00
C		0.52	0.10	0.84	1.38	0.67	0.67	1.22	0.00	1.00	1.28	0.76	0.63
D		1.05	0.01	0.99	0.80	0.94	0.46	1.17	0.07	0.94	0.44	0.15	0.75
M		3.48	0.04	0.95	0.67	0.45	0.66	0.72	0.04	0.90	0.51	0.32	0.69

as indicated by the absence of any overlap between groups in days to a criterion of an index of at least 0.95 ($U = 0$, $p = 0.028$). There also was no overlap between groups in mean index on Days 1 to 6 inclusive.

In Phase II, when the *mult* VI 15-sec VI 15-sec schedule was in effect, all birds in both experimental groups responded at a higher rate in the constant (red) than in the variable component on the first day. Within two or three days there was no systematic difference in rate during the two components except in the data of one bird. This Group K-VI subject responded about twice as often in the variable as in the constant component during the last five days and is responsible for decline of the index for Group K-VI below 0.5.

The right-hand section of Figure 1 shows that during Phase III the K-VI birds maintained differential responding on odd (*mult* VI-EXT) days although the index was not quite as high as during Phase I, and responded at about the same rate to both components on even (*mult* VI-VI) days. The H-VI birds clearly responded differentially only on the first day of Phase III when the extinction component lasted 4 min. Subsequently their mean index remained slightly above 0.5 on both *mult* VI-VI and *mult* VI-EXT days.

Figure 2 shows mean rate of responding in pecks per minute during the constant component for each day during Phases I to III for Group K-VI and K-VT. A comparison of mean rate for Group K-VI during Phases I (*mult* VI 15-sec EXT) and II (*mult* VI 15-sec

VI 15-sec) suggests a contrast effect (decreased rate during Phase II). Examination of Table 2 shows that all K-VI birds responded less to red on the last four days of Phase II than they had at the end of Phase I. As can be seen in Figure 2, rate of responding during red for K-VI birds during Phase III was a great deal higher on the *mult* VI EXT schedule than on the *mult* VI VI schedule. During Phase III, every K-VI bird increased rate of responding to red on odd (*mult* VI 15-sec EXT) days and decreased rate on even (*mult* VI 15-sec VI 15-sec) days. This is a rather striking example of behavioral contrast.

Results for the K-VT birds indicate that considerable autopecking during red was acquired during Phase I and was eliminated during Phase II. These results, which are representative of the three of the four K-VT birds that acquired a high pecking rate, are comparable to the results of other autopecking experiments (*e.g.*, Gamzu and Williams, 1971; Gamzu and Schwartz, 1973). During Phase III, the three K-VT birds that had attained high rates of autopecking showed the same regular increases and decreases in rate of responding to red that characterized the behavior of the K-VI subjects.

Figure 3 shows mean rate of responding during the constant (red) component by both houselight groups. Group H-VI pecked at about the same moderate rate throughout all three phases; there is no suggestion of contrast. H-VT birds all pecked the key during red on most days and each pecked at a rate of three per minute or higher on at least one day. However, each H-VT bird's mean rate

Fig. 3. Mean responses per minute during the constant component (red) for Groups H-VI and H-VT during Phases I to III.

during red on all days combined was lower than the rate of any subject in any other group. The rate of pecking red by Group H-VT is surprisingly high, as autopecking has been largely restricted to stimuli localized on the response key (Wasserman, 1973).

Figure 4 shows the mean rate of pecking during red on each day for birds in Group K-VI (also shown in Figure 2) and a second curve plotted from data obtained from the other three groups used to "predict" what the results should be for Group K-VI. These predicted values were obtained by adding mean rate of pecking during red by Group K-VT (responses due to stimulus-directed autopecks) to the difference between mean rate of Group H-VI minus mean rate of Group H-VT (pecks due to response-dependent food reinforcement). The parallel between the rates and rate changes for Group K-VI and those predicted from the other groups is striking. In fact, it is

Fig. 2. Mean responses per minute during the constant component (red) for Groups K-VI and K-VT, during Phases I to III.

Fig. 4. Mean responses per minute for Group K-VI and predicted from the performance of the other three groups. See text for further details.

surprising that the two curves are so similar; one might expect some interaction between the two processes, rather than a simple summation of the effects.

DISCUSSION

The results clearly confirm and extend Gamzu and Schwartz's (1973) findings indicating a close association between autopecking and behavioral contrast. The relationship is demonstrated by (1) parallel shifts in rate of pecking during red by K-VI and K-VT birds (Figure 2), (2) the failure to obtain contrast in Group H-VI, even though differential responding to variable-interval and extinction components was clearly evidenced during Phase I, and (3) the similarity of the obtained and "predicted" rates shown in Figure 4.

It is not clear if these results would be obtained with somewhat different procedures. Our procedure was selected to maximize autopecking and differed somewhat from the procedures typical of contrast experiments; namely, in our experiment: (1) the multiple schedule with different components (VI 15-sec EXT) was presented before the schedule with two identical components (VI 15-sec VI 15-sec), (2) some of our components were shorter (20 sec) than usual (1 to 4 min), and (3) our VI schedules were richer (VI 15-sec rather than VI 1- to 3-min). There is, however, no particular reason to expect such differences in procedure to be critical.

The failure of Group H-VI birds to respond differentially to variable-interval and extinction components on odd-numbered days during Phase III was unexpected. It is not clear why stimulus control failed for H-VI birds during Phase III. Since in preliminary experimentation pigeons from the same stock as our subjects had shown differential behavior to red, blue, and green houselights it seems unlikely that the H-VI subjects were unable to discriminate the stimuli associated with different component stimuli. Thus, it may be that the difference in the index of differential responding for the two VI groups during Phase III is due to autopecking tendencies. Presumably these tendencies would increase pecking during red only for Group K-

VI. Pecking might also be inhibited for this group during the stimulus associated with extinction.

The present procedure differed from that ordinarily employed in behavioral contrast experiments in that the stimulus associated with the variable component of the multiple schedule was different for each of the two multiple schedules employed. While this procedure has certain limitations it also has distinct advantages. The contrast effect obtained in K-VI birds during Phase III provides dramatic evidence of a strong contrast effect. The technique of employing different stimuli with each component schedule and providing different multiple schedules on an alternate or random sequence of sessions should be especially well-suited to settling questions of whether or not contrast continues throughout extensive training or under just what conditions it is lost if training is long continued (Terrace, 1972). Other procedures do not permit as good control for factors such as shifts in motivational level, which might produce a gradual change in rate of responding over a period of weeks.

REFERENCES

- Brown, P. L. and Jenkins, H. M. Auto-shaping of the pigeon's key-peck. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 1-8.
- Gamzu, E. and Schwartz, B. The maintenance of key pecking by stimulus-contingent and response-independent food presentation. *Journal of the Experimental Analysis of Behavior*, 1973, 19, 65-72.
- Gamzu, E. and Williams, D. R. Classical conditioning of a complex skeletal response. *Science*, 1971, 171, 923-925.
- Rachlin, H. Contrast and matching. *Psychological Review*, 1973, 80, 217-234.
- Terrace, H. S. By-products of discrimination learning. In G. H. Bower (Ed.), *The psychology of learning and motivation: advances in research and theory*. Vol. 5. New York: Academic Press, 1972. Pp. 195-265.
- Wasserman, E. A. The effect of redundant contextual stimuli on autoshaping the pigeon's keypeck. *Animal Learning and Behavior*, 1973, 1, 198-206.
- Williams, D. R. and Williams, H. Auto-maintenance in the pigeon: sustained pecking despite contingent non-reinforcement. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 511-520.

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