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FOOD-AVOIDANCE IN HUNGRY PIGEONS, AND OTHER PERPLEXITIES[1]

R. J. HERRNSTEIN AND D. H. LOVELAND

HARVARD UNIVERSITY

Twenty-three pigeons were subjected to a series of procedures in which the key-peck's effects ranged from immediate, differential food reinforcement, through delayed reinforcement, the production of stimulus changes with and without probable secondary reinforcement, the prevention of food presentation ("food-avoidance"), to extinction. Neither primary nor secondary food reinforcement appeared to be essential for the maintenance or acquisition of key pecking. The food-avoidance contingency failed to suppress responding in any subject. Only complete extinction, when pecking produced neither food nor stimulus changes, eliminated all pecking for most subjects. A combination of stimulus-change reinforcement and food reinforcement appeared to account for the results, but only if it could be assumed that the presence of food in a procedure enhanced the reinforcing power of stimulus change, whether or not the food was also dependent upon responding. Such an interaction between reinforcers may be involved in the phenomenon of autoshaping.

The setting for the present experiments may be suggested by a hypothetical experiment on a pigeon (see Figure 1). Imagine first (Figure 1a) that the pigeon, hungry and enclosed in a chamber containing a pair of conventional response keys (A, B), receives a bit of food for pecking A when it is lit. Key A gets lit irregularly, but once lit, stays that way for 6 sec or until the pigeon pecks it, whichever comes first. The continuously lit B provides a measure of "spontaneous" pecking, in that pecks at it do nothing. Since only the light on A signals food, one may safely predict that (1) A would be pecked when lit, (2) A would not be pecked much otherwise, and (3) B would not be pecked much at all. Now imagine the reverse procedure (see Figure 1b), with the opposite response contingencies during lit periods on A, as follows:

		Procedure	
		1 (see Fig. 1a)	2 (see Fig. 1b)
Response	peck	food + key light off	key light off
	6 peck-free sec.	key light off	food + key light off

In the second procedure, food comes for six peck-free seconds, and a peck is equivalent to six peck-free seconds in the first procedure, turning off the light and yielding no food. Pecking or non-pecking on B has no effect in either procedure. By the ordinary logic of operant research, procedure 2 should be the reverse of procedure 1 as far as pecking on A is concerned. If lighting A had facilitated pecking in the first procedure, it should inhibit it in the second.

The hypothetical experiment bears thought, for, owing to the work of Williams and Williams (1969), such expectations are substantially false. Pigeons actually subjected to what has been here called procedure 2 pecked at A during periods of illumination even when reinforcement occurred only after six peck-free seconds. Williams and Williams, along with others in recent years (see review by Segal, *in press*), have shown that something other than arbitrary connections among stimuli, responses, and reinforcers is complicating the elegant simplicity of the law of effect. The present experiments explored these complexities further.

EXPERIMENT 1

In the standard discrimination procedure, some stimulus sets the occasion for the reinforcement of a response, while the absence of

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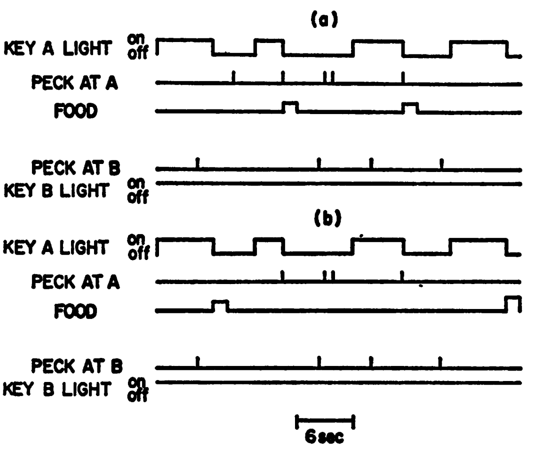

Fig. 1. Two procedures (a and b) in a hypothetical experiment. In procedure a, Key-A-pecks at illuminated Key A produce food. Periods of illumination on Key A terminate with a peck or 6 sec, whichever comes first. In procedure b, food comes after six peck-free seconds of illuminated Key A. As before, periods of illumination on Key A terminated with a peck or 6 sec, whichever comes first. In both procedures, pecking B is ineffective and B is always illuminated.

the stimulus sets the occasion for non-reinforcement. The contribution of differential reinforcement is typically shown by omitting reinforcement, thereby extinguishing the response. A tacit assumption holds that the response would also vanish, or at least weaken, if reinforcement still occurred, but non-differentially with respect either to the response or to the stimulus, for then the stimulus no longer "sets the occasion" for the reinforcement of the response. Experiment 1 tests that assumption.

METHOD

Subjects

Eight White Carneaux male pigeons, with experimental histories in a variety of procedures, worked at approximately 80% of their free-feeding weights.

Apparatus

A conventional one-key pigeon chamber served for all these experiments. The inner dimensions of the subject's chamber measured 11.5 by 11.5 by 12 in. (29 by 29 by 30.5 cm). The key, which required 13.5 g (0.135 N) to operate, was centered at a height of 9 in. (22.5 cm) on one wall, 5.5 in. (13.5 cm) above the 2 by 2 in. (5 by 5 cm) opening into the feeding space. The reinforcer consisted of presentations of grain for 1.5 sec, during which time two 7-w bulbs illuminated the food magazine. Christmas-tree bulbs of various colors transilluminated the response key. Two white bulbs provided additional light in the chamber. Pecking the key operated a relay for auditory feedback. White noise, piped into the box during all experimental sessions, masked irrelevant sounds.

Procedure

General. Various features of the procedure were common throughout (except where noted). The reinforcer was always a 1.5 sec operation of the feeder. Sessions were composed of a fixed number of consecutive "cycles" of fixed duration. Each cycle had two successive portions, called the "trial" (T) and the "signal" (S), denoted by the color of the key. Thus, a cycle might consist of 18 sec of green light ("trial") followed by 2 sec of white light ("signal"). The cycle would here be 20 sec, whatever else might be happening.

Experiment 1. See Table 1.

Group I. (a) Differential food reinforcement. Four pigeons with a history of reinforced key pecks started off with trial = 18 sec and signal = 2 sec. For Pigeons 89RP and 34GP, the order of illumination was green and white; for the other two, 35GP and 232 YP, the reverse. Cycles without a peck alternated T (trial) and S (signal). A peck during T immediately produced S, and then, 2 sec later, reinforcement ("Rf"). The remainder of the 20-sec cycle (not counting reinforcement time) passed in the dark ("B"). Pecks during S had no effect at any time. Sessions terminated after 120 cycles.

Group I. (b) Differential food reinforcement. After 17 sessions of the foregoing, these four pigeons were given 22 additional sessions differing only in the durations of T (19.5 sec) and S (0.5 sec).

Group I. (c) Non-differential food reinforcement. Reinforcement was now non-differential in the sense that it came in every cycle, whether or not there was a peck. As before, a peck during T immediately produced S, and then, 0.5 sec later, reinforcement. Sessions consisted of 120 reinforcements, as well as 120 cycles.

Group II. (a) Non-differential food reinforcement. Another four pigeons with histories of reinforced pecking started off with T = 18

Table 1

Experiment 1

	Trial (T) (sec)	*Signal (S) (sec)*	*# Sessions*	*Peck-Free Cycle*	*Peck Consequence*	*Results (% trials containing peck)*	
						Mdn	*Range*
Group I	a) 18	a) 2	a) 17	a) T + S	a) S + Rf* + B**	a) 99.5	a) 87-100
	b) 19½	b) ½	b) 22	b) T + S	b) S + Rf + B	b) 100	b) 99-100
	c) 19½	c) ½	c) 22	c) T + S + Rf	c) S + Rf + B	c) 100	c) 99-100
Group II	a) 18	a) 2	a) 17	a) T + S + Rf	a) S + Rf + B	a) 99	a) 95-100
	b) 19½	b) ½	b) 22	b) T + S + Rf	b) S + Rf + B	b) 100	b) 95-100
	c) 19½	c) ½	c) 22	c) T + S	c) S + Rf + B	c) 100	c) 100-100

*Rf = food reinforcement.

**B = blackout.

and S = 2 sec (258YP and 348GP had green and white, respectively; 261YP and 299YP had the reverse). However, reinforcement was non-differential for this first procedure, as in the procedure for Group I. (c), immediately above.

Group II. (b) Non-differential food reinforcement. T changed to 19.5 sec; S changed to 0.5 sec.

Group II. (c) Differential food reinforcement. For 22 sessions, reinforcement was differentially contingent on pecking. This procedure is identical to that used under Group I. (b), above.

RESULTS

The results appear in the last column of Table 1, as medians and ranges of the mean performance over the final 10 sessions for each pigeon in every procedure. All eight pigeons pecked on almost every trial, irrespective of differential reinforcement. Group I started with the conventional procedure, with food being given only on trials containing a response. Group II started with the unconventional procedure, with food presented regardless of pecking. The pigeons in both groups pecked on virtually every trial, with no apparent differences between them. Switching the conditions for the two groups also had no apparent effect (see transitions from b to c in Table 1). All pigeons continued to peck on almost every trial. No effect could be seen of the keylight color (which was successively green and white for half the pigeons and *vice versa* for the other half in both groups).

DISCUSSION

It makes no difference whether the trial stimulus serves a discriminative function in order for it to produce virtually 100% responding. In fact, the defining feature of a discriminative stimulus—that it signals differentially the availability of reinforcement—is apparently immaterial here, since both groups responded under both conditions. Note that pecking in the non-differential condition (Group I. c and Group II. a and b) does not contribute to the overall rate of food reinforcement because the 20-sec cycle always runs its course, no matter how early in the cycle the pigeon responds. Pecking does not, in that procedure, literally cause (in the sense of necessity) the presentation of food. Nor does pecking adventitiously "cause" food presentation, for a peck could be no closer to the food than 0.5 sec and many forms of responding besides pecking had at least an equal (or better) opportunity to be adventitiously correlated with food.

Perhaps, however, pecking in the non-differential procedure was reinforced by the signal itself, which presumably became a secondary reinforcer by virtue of its pairing with food. Or, perhaps pigeons prefer food sooner rather than later, which is what pecking does in the non-differential procedure, even though it does not change the over-all rate of reinforcement. Because Experiment 1 examined neither of these possibilities, they were studied in Experiment 2.

EXPERIMENT 2

Subjects

Four additional White Carneaux male pigeons, again with various experimental histories, worked at approximately 80% of free-feeding weights.

Table 2

Experiment 2

	Trial (T) (sec)	*Signal (S) (sec)*	*# Sessions*	*Peck-Free Cycle*	*Peck Consequence*	*Results (% trials containing peck)*	
						Mdn	*Range*
Group III	a) 18 b) 19½ c) 19½	a) 2 b) ½ c) ½	a) 17 b) 22 c) 22	a) T + S b) T + S c) T + S + Rf	a) B + S + Rf b) B + S + Rf c) B + S + Rf	a) 98 b) 99 c) 86	a) 97-100 b) 95-100 c) 19-99

Procedure. See Table 2.

Group III. (a) Differential/food reinforcement. The four pigeons started off with 20-sec cycles consisting of 18 sec of trial (T) and 2 sec of signal (S). For 275YP and 39YP, T was green and S was white; for 274YP and 47YP, the order was reversed. A peck during T initiated the blackout (B), which occupied the remaining duration of T, then followed by S and, finally, by the food (Rf). Pecks during S had no effect, here or in the other procedures. Sessions terminated after 120 cycles.

Group III. (b) Differential food reinforcement. T changed to 19.5 sec; S changed to 0.5 sec.

Group III. (c) Non-differential food reinforcement. Food reinforcement added to cycles without a peck, so that sessions now contained exactly one reinforcement for each of the 120 cycles. Since food came at the end of a cycle whether or not a peck had occurred, pecking simply substituted a blackout for the remaining duration of T within any cycle.

RESULTS

As Table 2 shows, the differential reinforcement condition (a and b) sustained pecking on virtually all trials, whether trial duration was 18 or 19.5 sec. Once again the medians and ranges for the four pigeons are shown, based, as before, on the mean number of trial responses per session for the last 10 sessions before a change in conditions. The means all fell between 95% and 100%, inclusive. The shift to the non-differential condition, reduced the frequency of responding (to 19% and 72%) for two of the pigeons (275YP and 39YP), but left it unchanged (at 99%) for the other two. It is worth noting that responding fell for the pigeons for which T was green, but not for the two for which it was white. The session-to-session data gave no sign that additional sessions would have produced more or less responding.

DISCUSSION

In conventional terms, the differential procedure (a and b) would be called a type of delay of reinforcement, since a response produced a stimulus (the blackout), followed some time later by a signal and food. At least the blackout, and perhaps the signal as well, should become secondary reinforcers. The uncertainty concerning the signal arises because pairing with food occurred only when there has been a peck during the trial. On other trials, the signal occurred without food. The blackout here was the unique and invariable correlate of food, with a delay equal to the duration of the signal (2 sec in the first procedure, 0.5 sec thereafter). Since there were pecks in virtually every trial, both the blackout and the signal should become secondarily reinforcing. Thus, there appears to be more than enough support for pecking in the differential procedure, from the primary reinforcer (taking that to be the food, at this stage), from one or another secondary reinforcer, or from all of the foregoing.

In contrast, for the non-differential procedure, c, pecking seems to have nothing to commend it from the standpoint of conventional theory. Pecking did not cause food and did not even move the food forward in the cycle. It did not turn on the signal (S), which comes closest to the food, temporally speaking. The only thing the peck did here was to produce the blackout, which must now, by the conventional theory, be a lesser secondary reinforcer than S, because it is more separated from the primary reinforcer in time, and it is no longer the unique correlate of food. Hardly enough of a positive effect, it would seem, to account for the 86% median frequency of pecking.

Nevertheless, some support (or at least some defense) for the conventional theory can be claimed. Two of the pigeons showed a lessened tendency to peck here as compared to the non-differential procedure in Experiment 1. Looking only at them, we might argue that the pecking in the non-differential procedure in Experiment 1 must have been due either to secondary reinforcement, to a reduction in delay of reinforcement, or both. But that leaves unaccounted for the two pigeons in Experiment 2 which pecked in almost every cycle without benefit of those standard props. Perhaps for them, the answer is that even though the blackout was a weaker conditioned reinforcer than S, it was still stronger than T. The pigeons may, by this argument, be working to rid themselves of T, the stimulus least closely related to food of the three arbitrary stimuli that are identified in Table 2 (*i.e.*, T, S, and B).

Whatever the plausibility of this last point, it should be noted that Experiments 1 and 2 together amply show that responding is sustained to some degree even when the contingency of food reinforcement is so highly tenuous as to be virtually invisible. It would be natural to wonder whether food really counts at all in some of the foregoing procedures, particularly when it comes non-differentially, or whether just the stimulus changes produced by pecking would suffice.

EXPERIMENT 3

Subjects

The 12 pigeons in the two previous experiments, still working at 80% free-feeding weights and still in Groups I, II, and III, as identified before, served.

Procedure. See Table 3.

Group I. (*a*) *Non-differential non-reinforcement* (*i.e., extinction of food*). Cycles without a peck consisted of 19.5 sec of trial (T) followed by 0.5 sec of signal (S). The order of colors was still green and white for 89RP and 34GP and reversed for 35GP and 232YP. A peck during T immediately turned on S for 0.5 sec and the remainder of the cycle was spent in the dark (B). There was no food given at any time during the session, which again continued for 120 cycles.

Group I. (*b*) *Reconditioning with non-differential food reinforcement.* Food was reinstated for all cycles, not just those containing a peck. Peck-free cycles had the food at the end; a peck during T produced S for 0.5 sec, followed by food and then the blackout for the remainder of the cycle. The trial duration was now 59.5 sec, making the cycle 60 sec. Sessions terminated after 60 cycles.

Group II. (*a*) *Non-differential non-reinforcement* (*i.e., extinction of food*). Identical to procedure for Group I. a as described above. 258YP and 348GP had green followed by white keylights during each cycle; 261YP and 299YP had the order reversed. Sessions ran for 120 cycles.

Group II. (*b*) *Reconditioning with differential food reinforcement.* Food reinforcement occurred only in cycles containing a peck. Peck-free cycles consisted of 59.5 sec of T followed by 0.5 sec of S. A peck during T turned on S for 0.5 sec, then food, and then the blackout for the remainder of the 60-sec cycle. Sessions terminated after 60 cycles.

Group III. (*a*) *Non-differential non-reinforcement* (*i.e., extinction of food*). Peck-free cycles consisted of 19.5 sec of trial (T) followed by 0.5 sec of signal (S). The order of colors was still green and white for 275YP and 39YP, and reversed for 274YP and 47YP. A peck during T produced the blackout for the remaining duration of T, then followed by S. No food

Table 3

Experiment 3

	Trial (T) (sec)	*Signal (S) (sec)*	*# Sessions*	*Peck-Free Cycle*	*Peck Consequence*	*Results (% trials containing peck)*	
						Mdn	*Range*
Group I	a) 19½	a) ½	a) 21	a) T + S	a) S + B	a) 12	a) 2-35
	b) 59½	b) ½	b) 167	b) T + S + Rf	b) S + Rf + B	b) 100	b) 100-100
Group II	a) 19½	a) ½	a) 21	a) T + S	a) S + B	a) 9	a) 3-10
	b) 59½	b) ½	b) 167	b) T + S	b) S + Rf + B	b) 100	b) 100-100
Group III	a) 19½	a) ½	a) 21	a) T + S	a) B + S	a) 6	a) 5-45
	b) 59½	b) ½	b) 264	b) T + S + Rf	b) B + S + Rf	b) 91	b) 56-96

was given at any time during sessions, which ran for 120 cycles.

Group III. (b) Reconditioning with non-differential food reinforcement. Food was reinstated for all cycles, not just those containing a peck. Food always came at the end of the cycle (now 60, instead of 20, sec). In peck-free cycles, the order of events was: T (59.5 sec), S (0.5 sec), food. A peck during T produced blackout for the remaining duration of T, then S followed by food. Sessions terminated after 60 cycles.

RESULTS

Table 3 summarizes the data for all subjects, again as medians and ranges of the means of the final 10 sessions for each condition. As would be expected, pecking subsided in the absence of food. However, it did not cease entirely, for it hovered around 2 to 45% for all subjects even after 21 sessions of extinction, *i.e.,* after over 2500 food-free trials. After the first 10 sessions of extinction, day-to-day responding rose and fell with little regularity or consistency, and with no apparent upward or downward trend. Given the broad ranges of variation, nothing can be made of the relatively small differences in the medians for these groups. Similarly, there was no consistent effect of the order of key colors within cycles.

Recovery swiftly followed extinction for all 12 subjects. Compared to the comparable procedures in Experiments 1 and 2, the shift to a 60-sec cycle and a 60-cycle session did not seem to have a major effect on per cent responding. Note that for Groups I and III, reconditioning meant non-differential reinforcement, with frequency of reinforcement unaffected by pecking. Except for the change in T-duration, this repeated procedure c for Group I in Experiment 1 and procedure c for Group III in Experiment 2. Responding by one pigeon in Group III rose from 19% to 91%, but otherwise all pigeons returned to their approximate prior levels of pecking. The one remaining low (*i.e.,* less than 90%) responder (275YP in Group III) pecked on 56% of trials. Group II showed perfect recovery (compare with procedure c in Experiment 1), with all pigeons again responding on every trial for differential reinforcement. Pecking persisted for 10,020 cycles of non-differential reinforcement for Group I and for 15,840 cycles for Group III.

Table 4

Latency to Peck During T
Sec

		Mdn	*Range*
Group I	b)	1.48	1.32- 1.98
Group II	b)	1.69	1.40- 2.09
Group III	b)	14.29	10.43-20.73

Latencies, tallied for procedure b (the reconditioning phase) for each group appear in Table 4. Only trials containing a peck are included in these data; time spent in peck-free trials would have artificially inflated the average latencies for pigeons that pecked less often than in every cycle. Groups I and II responded about equally rapidly, with a median latency of about 1.5 sec. In contrast, Group III responded significantly more slowly, with median latency over 14 sec. The mean latencies for the individuals in Groups I and II did not overlap those of Group III.

DISCUSSION

Both the frequencies of responding (Table 3) and the latencies (Table 4) suggest greater similarity between Groups I and II than between either of these and Group III. Yet, food reinforcement was non-differential for Groups I and III, but differential for Group II. Experiments 1, 2, and 3 unanimously failed to show any distinction between differential and non-differential reinforcement. Groups I and II consistently differed from Group III—with the former two showing higher response probability and shorter response latency—but presumably because pecks moved the presentation of food forward in time only for the first two groups. For none of the groups, however, did it appear to matter whether or not the presentation of food actually depended upon the peck.

Experiment 3 mainly sought to find out whether food played any role whatever in the pecking during the various non-differential procedures. The answer is clearly affirmative to a degree, for pecking greatly declined without food. Responding may thus arise somehow from primary reinforcement even without a direct dependency between response and reinforcement or, in the case of Group III, without a direct temporal association between them. How this might happen is further considered in the General Discussion.

Extinction of food produced an unanticipated persistence of responding. All 12 pigeons continued to peck in at least a few trials a session—averaging about 9%—even after more than 2500 food-free cycles. Although this clearly exceeds the usual standards for persistence, it may have been simply the result of using experimentally well-trained subjects, as all 12 were. And there may be certain features of the foregoing reinforcement schedules (differential and non-differential) that favored exceptionally long-lasting secondary reinforcement. The next experiment considered both of these alternatives.

EXPERIMENT 4

Subjects

The 12 pigeons from the foregoing experiments (*i.e.*, Groups I, II, and III) served, plus 11 experimentally naive White Carneaux male pigeons (*i.e.*, Groups IV and V) whose only prior exposure to the apparatus afforded two days of feeder training with the key covered. The new subjects had never experienced any explicit reinforcement for pecking the response key. All subjects worked at approximately 80% of free-feeding weights.

Procedure. See Table 5.

Group I. (*a*) *Differential non-reinforcement* (*i.e., negative food contingency*). Cycles without a peck consisted of 59.5 sec of T, followed by 0.5 sec of S, then food. A peck during T immediately turned on S for 0.5 sec, and then a blackout for the remainder of the 60-sec cycle, each peck during T thus eliminating one presentation of food. The order of key colors was as in the three prior experiments for this group. Sessions lasted 60 cycles.

Group II. (*a*). Identical to Group I. a described above.

Group III. (*a*) *Differential non-reinforcement* (*i.e., negative food contingency*). Cycles without a peck consisted 59.5 sec of T, followed by 0.5 sec of S, then food. A peck during T initiated a blackout for the remaining duration of T and was followed by 0.5 sec of S. Each peck during T therefore eliminated exactly one presentation of food. Only the order of S and the blackout following a peck differed between this procedure and that for Groups I and II. The order of key colors for T and S was as in the prior experiments for this group. Sessions lasted 60 cycles.

Group IV. (*a*). Identical to Group I. a described above. There were eight experimentally naive (see Subjects, above) pigeons in this group, of which 5WP, 6WP, 9WP, and 10WP had green and white as the order of key colors during each cycle and 7WP, 8WP, 11WP, and 12WP had the reverse.

Group IV. (*b*). Identical to Group III. a described above.

Group V. (a). Identical to Group III. a described above. There were three experimentally naive (see Subjects, above) pigeons in this group, of which 25WP had green and white as the order of key colors during each cycle and 27WP and 28WP had the reverse.

Group V. (*b*). Identical to Group I. a described above.

RESULTS

Table 5 gives medians and ranges of the 10-day means for each of the five groups. The negative food contingency eliminated pecking no better for Groups I, II, and III than had simple extinction of food in Experiment 3. More than 5000 cycles of the penalty for pecking left

Table 5

Experiment 4

	Trial (T) (sec)	*Signal (S) (sec)*	*# Sessions*	*Peck-Free Cycle*	*Peck Consequence*	*Results (% trials containing peck)*	
						Mdn	*Range*
Group I	a) 59½	a) ½	a) 97	a) T + S + Rf	a) S + B	a) 15	a) 1-28
Group II	a) 59½	a) ½	a) 97	a) T + S + Rf	a) S + B	a) 11.5	a) 7-16
Group III	a) 59½	a) ½	a) 86	a) T + S + Rf	a) B + S	a) 8	a) 4-28
Group IV	a) 59½	a) ½	a) 79	a) T + S + Rf	a) S + B	a) 8.5	a) 0-65
	b) 59¼	b) ½	b) 18	b) T + S + Rf	b) B + S	b) 10	b) 2-39
Group V	a) 59½	a) ½	a) 69	a) T + S + Rf	a) B + S	a) 4	a) 0-7
	b) 59½	b) ½	b) 240	b) T + S + Rf	b) S + B	b) 5	b) 1-6

the frequency in the vicinity of 10%, roughly the level produced when food was omitted. For a minimum of about 70 of the 86 to 97 sessions of the procedure (*i.e.,* for about 4200 cycles), the frequency of pecking hovered erratically in the indicated range for all subjects. Further exposure to the procedure did not seem likely to produce significant changes.

Groups IV and V, containing only naive subjects, substantiate the results just summarized. All of the new pigeons eventually started pecking the key even though there was differential reinforcement for non-pecking. The eight pigeons in Group IV first encountered the procedure in which a peck turned on S; the three in Group V, the procedure in which a peck turned on the blackout. One pigeon in each group failed to peck on its first procedure. However, after the two groups swapped procedures, those last two subjects began pecking, albeit infrequently. There was less pecking among the new pigeons in general than among the original 12, but not enough less to be significant by any statistical test, given the ranges. To a first approximation, then, all groups responded persistently, but relatively infrequently, with no clear differences among them.

The data from all 23 subjects, pooled according to whether a peck produced S or blackout, appear in Table 6 as quartiles based on the usual 10-session means. For the first procedure (*i.e.,* peck turned on S), N equalled 19 (four each from Groups I and II, eight from Group IV, and three from Group V); for the other procedure (*i.e.,* peck initiated the blackout) N equalled 15 (four from Group III, eight from Group IV, and three from Group V). Not only the medians, but also Q_1 and Q_3, match within a few per cent, suggesting that even the details of the distribution of peck frequencies are similar.

Latencies, too, revealed no difference between the two procedures, as shown in Table 7. The results for only Groups IV and V are given, but they are representative of all the groups. The over-all median latency for cycles containing a peck was in the vicinity of 23 sec, approximately 7 sec less than half the cycle. (As before, the calculation uses only cycles containing a peck.) For neither group taken alone, nor for the two combined, does it seem to matter whether the peck turned on the blackout or S first. The data for individual subjects suggest something of a negative correlation between over-all response probability and average latency, but slightly at best. Even for subjects that pecked only very rarely, the latency almost never exceeded 45 to 50 sec.

Table 7

Latency to peck during T (sec)

	S + B		*B + S*	
	Mdn	*Range*	*Mdn*	*Range*
Group IV a)	19	10-30		
Group IV b)			22	9-46
Group V a)			27	17-33
Group V b)	27	9-39		
Combined IV & V	19	9-39	24	9-46

Table 6

% Trials Containing Peck

	Peck Consequence	
	S + B	*B + S*
Q_1	1	4
Mdn	7	9
Q_3	18	19

The order of presentation of colors within cycles turned out to be the single most potent variable in the experiment. Table 8 compares the quartiles for pecking a white key during T with pecking a green key during T. All the data summarized in Table 5 contributed to the quartiles. Table 8 grouped the data on the basis of key color alone, regardless of procedure. For white T, N equals 18; for green, 16. Although the conditions overlap, pecking during white illumination substantially exceeded pecking during green.

DISCUSSION

The 11 naive pigeons of Groups IV and V learned to peck the key even though each peck cost them one presentation of food. In light of that finding, the persistent pecking in Experiments 1, 2, and 3 may have been something

Table 8

% Trials Containing Peck

	White T	*Green T*
Q_1	4.5	1
Mdn	14	7
Q_3	27.5	9

more than a result of using well-trained subjects. It had been found in those earlier experiments that pecking continued even with non-differential reinforcement and non-differential non-reinforcement (as regards food). The negative food-contingency procedure (*i.e.,* differential non-reinforcement) took a further step towards making the key peck non-adaptive. By now, pecking is not only unadaptive, but actually maladaptive, at least as regards food. Nevertheless, taking all the pigeons together, pecking here approximately equalled that in Experiment 3 during extinction—about 10%, with substantial individual variation. It would take much larger groups to validate even moderately large differences in the average effects of the two procedures.

A conventional reinforcement-theory account of the negative contingency procedure might take the following form. On any peck-free trial, the pigeon's behavior leads to food (*i.e.,* primary reinforcement). At the same time, the stimulus just preceding the food—S—gets a conditioning trial to make it a secondary reinforcer. If pecking produced S, the pigeon might be disposed to peck to obtain it, gaining secondary reinforcement at the cost of primary. The relatively weak but persistent tendency to peck might, by this view, plausibly reflect how much more potent a reinforcer food is than S. The main trouble with this account is that pecking produced S for only one of two negative contingency procedures. For the other (Group III, Group IV. b, and Group V. a, see Table 5), the peck produced the blackout, not S. In this second procedure, pecking produced the one stimulus uniquely not associated with food, since the blackout came only in cycles containing a peck and therefore no food. Food, when it came (*i.e.,* on peck-free trials), was still preceded by S, which is therefore a conventional secondary food reinforcer. Consequently, for the pigeons that were producing the blackout, pecking cancelled food without affecting the secondary reinforcer (S). In addition to cancelling food, pecking replaced the trial stimulus with a stimulus that was never associated with food (the blackout). Yet as Table 6 shows, this procedure yields virtually the same frequency of pecking as the other negative contingency procedure. The lack of difference in latencies, shown in Table 7, underscores the same point. Pecks occurred mainly in the middle half of the trial, whether the result was to hasten S or turn off the light. Since the two negative-contingency procedures significantly differ in the opportunity for secondary reinforcement, the lack of a differential effect is critical for any conventional reinforcement-theory account. The close agreement in response frequencies and latencies (Tables 6 and 7) says that pecking has other support than food reinforcement, whether primary or secondary. Finally, Table 8, with its difference in responding depending on the color of the key, strongly suggests non-food factors, for color was counter-balanced with respect to food.

Having excluded a history of reinforced key pecking or secondary reinforcement as the basis of responding, Experiment 4 raised the possibility that pecking will occur on about 10% of the trials whatever its consequences. It now remains to be shown how pecking can be experimentally eliminated.

EXPERIMENT 5

Subjects

The 11 experimentally naive pigeons from Experiment 4 (Groups IV and V) worked at approximately 80% of free-feeding weights. These pigeons still had no history of food-reinforced key-pecking.

Procedure. See Table 9.

Group IV. (a) Non-differential non-reinforcement (i.e., extinction of food). The eight pigeons were given 84 daily sessions (60 cycles per session) without food in any cycle. Cycles without a peck consisted of 59.5 sec of T followed by 0.5 sec of S; the key colors were as before. A peck during T turned on S for 0.5 sec, the remainder of the cycle passed in the black-out.

Group IV. (b) Non-differential non-reinforcement (i.e., extinction of food). For 238 additional sessions, the only change from procedure a, above, concerned the order of events after a peck: blackout first, then S. Sessions continued for 60 food-free cycles, each running 60 sec.

Group IV. (c) Non-functional peck (i.e., total extinction). For 33 sessions, pecks had no effect on the sequence of stimuli. Pecking operated the auditory feedback relay in the chamber, the recording counters, and nothing else. Each cycle consisted of 59.5 sec of T and

Table 9

Experiment 5

	Trial (*T*) (*sec*)	Signal (*S*) (*sec*)	# *Sessions*	*Peck-Free Cycle*	*Peck Consequence*	*Results (% trials containing peck)*	
						Mdn	*Range*
Group IV	a) 59½	a) ½	a) 84	a) T + S	a) S + B	a) 45	a) 0-61
	b) 59½	b) ½	b) 238	b) T + S	b) B + S	b) 13	b) 0-57
	c) 59½	c) ½	c) 33	c) T + S	c) none	c) 0	c) 0-3
Group V	a) 59½	a) ½	a) 33	a) T + S	a) none	a) 1	a) 0-9

0.5 sec of S, pecking notwithstanding. Sessions ran for 60 food-free cycles of 60 sec each.

Group V. (*a*). Same as Group IV. c, described above.

RESULTS

In the first two procedures, a and b for Group IV, pecking neither produced nor prevented food, while the other features of the cycle were sustained. Table 9 shows that pecking continued nevertheless. Combining the two procedures gives 322 consecutive sessions with 19,320 food-free cycles, yet pecking lingered on. Although the median for the first procedure clearly exceeded that for the second (45% *versus* 13%), the ranges match almost exactly. For each procedure, one pigeon (the same one) pecked virtually never. Figure 2 shows the eight individual means for the two procedures as points and the medians as crosses. The third extinction procedure also shows in Figure 2 (and Table 9). When pecking became virtually non-functional (Group IV. c and Group V. a), it ceased entirely for eight of the 11 pigeons in the two groups and was at 1%, 3%, and 9% for the remaining three.

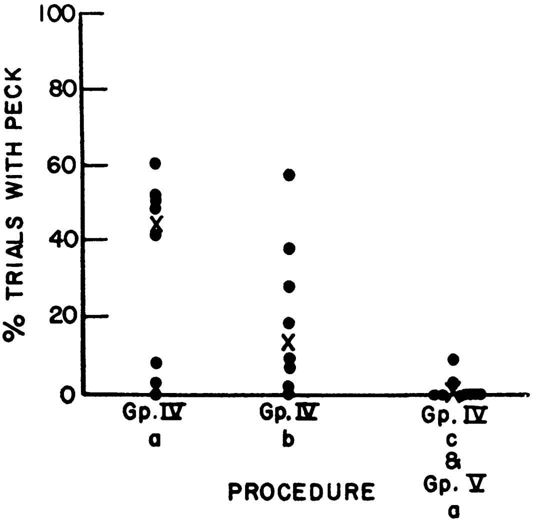

Fig. 2. Per cent trials containing a peck in several procedures (see Table 9 for specifications). Points show individual 10-session means; crosses show group medians.

The latency of a peck in cycles containing a peck appears in Table 10 (only for Group IV. a and b, the final procedure having too few pecks for a meaningful assessment). As with response probability (Table 9), the ranges agree but the medians differ, with the first procedure producing latencies almost twice those with the second. It is worth noting here the direct relation between response probability and latency, compared to the inverse relation in Experiment 4 (see Table 7 and associated text). For some subjects, response latency showed undeniable effects with the shift from procedure a (peck turned on S, then blackout) to procedure b (the reverse order of stimuli). For example, Pigeon 8WP pecked in 48% of the cycles with procedure a (final 10 sessions). At the same time, its mean daily latencies varied between 56.3 and 58.0 sec, a remarkably narrow range of less than 2 sec within the final 3.2 sec of T. By any reasonable definition, 8WP was timing its pecks to coincide with the end of T. From 238 to 248 sessions later, with procedure b, response probability had fallen to 28%, while the mean daily latencies varied between 22.5 and 29.6 sec, or less than half of T. In terms of relative precision (*i.e.*, variation divided by central tend-

Table 10

Latency to peck during T (sec)

	S + B	*B + S*
Mdn	45	24
Range	14-58	12-46

ency), the 7.1-sec variation with procedure b is more than an order of magnitude poorer than the 1.7-sec variation with procedure a. In summary, for 8WP, both the temporal location of a peck and its temporal precision changed between final sessions with a and those with b. Other subjects, however, showed other patterns of change, and still others showed none.

Experiment 4 contained a clear-cut color preference, with the subjects more likely to peck at white than at green. A similar tendency turned up in Experiment 2. The present experiment contained no such color preference. If anything, a slight, but probably insignificant, preference was shown for green.

Discussion

Two conclusions follow directly from these results. First, food extinction suppresses the pecking of experimentally "naive" (*i.e.,* no food-reinforced key pecking) pigeons no better than of the experienced subjects in Experiment 3. Second, removing all major consequences of pecking (food and stimulus change) brings it to a virtual halt. It may be that the operation of the auditory feed-back relay—the one remaining experimental consequence of pecking—accounts for the residuum in three of the 11 subjects.

Besides those clear findings, the data contain other possibly noteworthy, albeit statistically insignificant, features. Procedure a yielded more pecking than procedure b (Table 9). If real, the difference cannot be attributed to secondary reinforcement based on food, because food was absent for all 322 sessions of the two procedures. The difference may be plausibly explained by the order of conditions (if not by chance fluctuation), since procedure b lasted for 238 sessions after the end of procedure a, without any reversal of conditions. The latency difference between procedure a and b (see Table 10) may similarly not be explained by any difference in primary or secondary food reinforcement. The most that can be said is that for some subjects, there appeared to be sufficient conditions for timing, but whatever they were, there was no necessary relation between them and any of the experimental parameters.

Since pecking virtually disappeared with the final procedure, omitting both food and stimulus change, the possibility arises that all of the foregoing findings in the five experiments can be handled by combinations of food reinforcement and stimulus-change reinforcement. However, the data in hand seem to exclude any simple additive combination of the two reinforcers. Consider two procedures, one presenting food non-differentially, the other withholding food altogether, but both allowing pecks to change the stimuli. If food reinforcement and stimulus-change reinforcement added linearly, the two procedures should produce equal responding, entirely attributable to stimulus-change reinforcement since food comes non-differentially or not at all. Yet, the probability of pecking falls drastically without food, even non-differential food. Groups I and III in Experiment 3 went from about 9% to about 95% pecking when food was non-differentially added to pure stimulus-change procedures. However, since the subjects in Experiment 3 were experienced with food-reinforced key pecking and so may have pecked only because of their past histories, the next experiment attempted to replicate the finding with "naive" pigeons.

EXPERIMENT 6

Subjects

Seven pigeons from Group IV (excluding 10WP, which died) worked at approximately 80% of free-feeding weights. They still had no history of food-reinforced key pecking.

Procedure. See Table 11.

Non-differential food reinforcement. Food came at the end of all cycles, regardless of

Table 11

Experiment 6

	Trial (T) (sec)	*Signal (S) (sec)*	*# Sessions*	*Peck-Free Cycle*	*Peck Consequence*	*Results (% trials containing peck)*	
						Mdn	*Range*
Group IV	59½	½	48	T + S + Rf	B + S + Rf	64	1-83

pecking. A peck during T produced a blackout that finished the 59.5 sec of T and had no other effect. The same procedure was used in Experiments 2 and 3 for Group III (see Tables 2 and 3, respectively). Key colors, session duration, and all other parameters were unchanged.

RESULTS

Table 11 shows that all seven pigeons pecked on at least some trials, the range being from 1% to 83%, with a median of 64% based on the 10-session means.

DISCUSSION

Two comparisons are clearly relevant. First, Group IV, b in Experiment 5 should be compared with the same pigeons in Experiment 6. In Experiment 5, procedure b, a peck produced the blackout and had no other effect on the presentation of stimuli. Such is also the case in Experiment 6. Only the presence or absence of non-differential food distinguishes the two procedures. If additive combinations of food reinforcement and stimulus-change reinforcement could account for the data in this entire series of experiments, then there should have been no difference in pecking in the two cases, since non-differential food should add no strength to pecking. Instead, as Tables 9 and 11 suggest, the mere presence of food, without a contingency of reinforcement, favors the occurrence of pecking, even in these "naive" pigeons. Table 12, giving the quartiles for the two experiments, underscores this conclusion. The lowest quartile in Experiment 6 exceeds by more than 10% the highest quartile in Experiment 5. The pigeon (10WP) that contributed to Experiment 5 but not to Experiment 6, was the highest responder in Group IV, so that its elimination probably attenuated the difference between the two procedures.

The second relevant comparison pits the present results against those for the experimentally experienced pigeons in Group III (see Tables 2 and 3). Although the two groups overlap substantially, the comparison suggests a past-history effect favoring the experienced subjects. Medians of 86% and 91% for Group III are to be compared with the median of 64% for Group IV.

Table 12

% Trials Containing Peck

	Experiment 5 *Food* *Absent*	*Experiment 6* *Food* *Present*
Q_1	1	39
Mdn	13	64
Q_3	28	69

In Experiment 6, pigeons lacking any history of food-reinforced key pecking, which earned neither primary nor secondary food reinforcement by responding, pecked in more than 50% of the cycles. As noted earlier, pecking here produced the one stimulus uniquely correlated with non-reinforcement—the blackout. Neither food nor the conventional secondary reinforcer—S—was affected in any way by pecking. Yet both experienced (see Tables 2 and 3) and "naive" (see Table 11) pigeons continued to peck, although perhaps more in the first instance. Key pecking was somewhat controlled by food even when food was not controlled by key pecking, for without food, the frequency of pecking fell to a range of 10 to 15% for both experienced and naive subjects.

GENERAL DISCUSSION

Pigeons peck a key almost invariably when doing so produces food, as in Experiment 1. This is hardly surprising. However, the ordinary interpretation of "produce" entails a differential effect on the occurrence of food. Consequently, the equally high probability of pecking when food comes regardless of pecking (also as in Experiment 1) must be considered somewhat surprising. The roles played by various parameters of the first experiment—secondary reinforcement, sheer stimulus change, reduced delay-of-primary-reinforcement—were more or less directly assessed by the five subsequent experiments. For purposes of comparison, the 10-session means from all six experiments have been pooled for Table 13. Over-all medians and quartiles appear for the nine procedures that may be distinguished according to variations in the consequences of pecking and to the presence or absence of food. Table 13 disregards differences that may be of some importance, such as the past histories of the subjects, the color of the key illumination, and the over-all cycle duration. In the present series of experiments, however, these factors did not appear to make a consistent difference, and so the data are combined for convenience.

Table 13

% Trials containing peck

Peck Consequence		*1*	*2*	*3*	*4*	*5*	*6*	*7*[1]	*8*[1]	*9*[1, 2]
Food	a) Differential	+		+		–	–			
	b) Moved Forward	+	+							
Stimulus	a) S Moved Forward	+	+			+		+		
Change	b) Blackout			+	+		+		+	
	Q_1	100	100	95	55	1	4	4	5	0
	Mdn	100	100	99	72	11	9	10	7	0
	Q_3	100	100	99	90	25	19	42	28	1

[1] Food withheld in all cycles.

[2] Peck non-functional as regards food and stimulus change.

A procedural key heads each column. Column 1, for example, summarizes differential food reinforcement when a peck moved forward both food and S. In contrast, Column 3 also summarizes differential food reinforcement, but when a peck moved forward neither food nor S. This, in other words, summarizes Experiment 2, a and b, (see Table 2) in which pecks produced a blackout for the remaining duration of T and then S followed by food at the end. Columns 1 to 6 present all the procedures containing food, in any relation to pecking. For Columns 1 and 3, food was peck-dependent; for 2 and 4, peck-independent; and for 5 and 6, dependent on non-pecking (the "negative contingency" of Experiment 4). For Columns 7 and 8, food was omitted altogether and, finally, for 9, food was omitted and pecking controlled no stimulus changes.

Columns 1 and 2 present the evidence that non-differential food sustained pecking as well as differential food, just as long as the peck moved the food forward in the cycle. With food neither dependent on pecking nor moved forward by it (*i.e.,* Column 4), responding clearly declined, but did not stop altogether. Column 3 suggests that pecking may be ever so slightly diminished if it only produces food without moving it forward, but the difference between Column 3 and Columns 1 or 2 could easily be due to chance. Columns 5 and 6, showing the results of the negative contingency for food, place well below the first four columns. It apparently made no difference whether the peck moved S forward (Column 5) or whether it turned on the blackout (Column 6). As noted earlier, the lack of a difference between the procedures summarized in Columns 5 and 6 somewhat hobbles ordinary theories of secondary reinforcement. The absence of a substantial difference between Columns 5 and 6 not only says that secondary reinforcement fails to account for the pecking, but also that some factor besides food reinforcement or secondary food reinforcement should be sought. The case for some source of pecking other than food-related reinforcement gains further support from Columns 7 and 8, when food was absent altogether. None of the differences among Columns 5 to 8 inclusive reach statistical significance. However, the level of pecking for Column 9, when it produced neither food nor stimulus change, clearly falls short of any of the others.

Most conservatively, four levels of responding can be distinguished in Table 13. The highest, for Columns 1 to 3, has pecking in virtually all cycles. The next, Column 4, gets about 70% responding. Next, for Columns 5 to 8, pecking fluctuates at about 10%. And, finally, Column 9 is virtually peck-free. These cutting lines do not sort according to standard assumptions about operant behavior, which is doubtless the most interesting thing about them. If differential food reinforcement were as critical as ordinarily supposed, then there ought to be a respectable difference between Columns 1 and 2. Moreover, if the lack of the expected difference is taken as evidence for the power of S as a secondary reinforcer, then the lack of difference between Columns 5 and 6 becomes troublesome. The substantial level of pecking in Column 4, when pecking affected neither food nor S, seems to point to sheer stimulus change (or the blackout) as the reinforcer. But if so, why does pecking subside in Column 8, the identical procedure to Column 4 except that the (non-differential) food has been eliminated?

As noted throughout the paper, response probability fluctuated widely among subjects, and for each subject over time, particularly for the procedures that produced intermediate and low levels of responding. The procedures were at times only roughly keyed in to the underlying factors controlling pecking. And there were, it should be recalled, latency and stimulus-color effects that turned up occasionally, but inconsistently, further revealing a mismatch between the procedures and the controlling variables for the behavior. The disorderly features of the data are as telling as the clear findings noted in Table 13. To a considerable extent, neither are predicted by the standard operant account of the key-pecking behavior of pigeons.

The present results belong in the literature of behavior unexpectedly produced neither as ordinary reflexes nor as reinforced operants. In recent times, the literature may be dated from the Brelands' account of their efforts at practical animal training (1961). By titling their article "The Misbehavior of Organisms", they expressed succinctly both their expectations and disappointment. The behavior they kept encountering—such as the rooting of pigs, the scratching of chickens, or the washing movements of raccoons—was perfectly familiar to any observer of these creatures, but seemed nevertheless to violate the canons of both operant and respondent behavior. The growing literature on "induced" behaviors, ably reviewed by Segal (*in press*), brings the problem directly into the laboratory. How to deal with polydipsia, pica, shock-induced eating, copulation, and aggression (to pick a few examples)? They seem to be neither reflexive like a knee jerk nor instrumental like a key peck or a lever press. But most troubling has been the discovery that even the key peck and the lever press may "misbehave". The phenomenon termed "auto-shaping", as studied by Brown and Jenkins (1968), Rachlin (1969), Williams and Williams (1969), and Sidman and Fletcher (1968) further exemplifies behavior unexplained by either operant reinforcement or the classical eliciting stimulus. The special relevance of auto-shaping is that the behaviors at issue are standard responses in the animal-learning literature—key pecking in pigeons, panel pushing in monkeys. For obvious reasons, experimenters in this tradition will dwell on unexpected sources of those supposedly "arbitrary" responses if they turn out to be less arbitrary than had been supposed.

Consider key pecking in pigeons. In countless experiments, it has risen and fallen in rate as the contingencies of food reinforcement dictated. At the same time, however, no one has unequivocally succeeded in teaching a pigeon to peck a key to avoid an electric shock. The number of resounding failures to do so probably exceeds by orders of magnitude the handful of hard won but marginal successes (see Rachlin and Hineline, 1967), although the criteria for scientific publication interfere with such tallies. Nor can we conclude that pecking is intractable, for Williams and Williams (1969) and the present Experiment 4 report experimentally naive pigeons learning to peck when doing so *prevents* food. *Hungry pigeons peck a key more readily to avoid food than to avoid shock.*

It has been found here that pigeons peck a key for reasons other than primary or secondary differential food reinforcement. Allowing the peck merely to change the color of the keylight sustains it indefinitely, albeit at a low level. Not surprisingly, some color changes are sometimes more reinforcing than others (see Table 8, showing the apparent superiority of white-to-green over green-to-white). But whatever the details, this kind of reinforcement would, by itself, make possible the phenomenon of auto-shaping. However, the phenomenon is greatly enhanced by correlating food with the stimulus changes. The effect appears to be a genuine reinforcement interaction, not just secondary food reinforcement, as several of the present experiments demonstrated. Presumably, the pigeon pecks at salient objects, and the pairing of food with the changing appearance of the key makes the key more salient than otherwise.

The present experiments leave a number of questions unanswered. It remains to be shown what there is about food presentation that affects stimulus salience, what the essential features of stimulus-change reinforcement are, whether the peck has inherent reinforcing properties as regards salience. But whatever the answers to those questions, these findings, and the others like them accumulating in the literature, raise further, far broader, questions about the experimental method producing them. Skinner's approach to the law of effect (1938) followed from several simplifying assumptions. Among them was the belief that he could safely avoid what he called the "botanizing" of reflexes. As he said, "The number of stimuli to which it [*i.e.,* the organism] may come to respond through a process to be described below [*i.e.,* respondent conditioning] is indefinitely large, and to each of them it may be made to respond in many ways. It follows that the number of possible reflexes is for all practical purposes infinite and that what one might call the botanizing of reflexes will be a thankless task." (1938, p. 10) In effect, he was here repudiating J. B. Watson's program for behaviorism, which was "the ascertaining of such data and laws that, given the stimulus, psychology can predict what the response will be; or, given the response, it can specify the nature of the effective stimulus." (Watson, 1924, as quoted in Skinner, 1938, p. 10)

Skinner was thus skeptical about the practicability of the traditional reflexive approach to psychology, as exemplified by Watson and some of the other pre-Skinnerian behaviorists. Instead, said Skinner, the study of the operant, which is to say, of behavior defined by its environmental consequences, will finesse the entire issue, for the study of operants can disregard the varieties of behavior and focus on just one or two. He gave his reason clearly, even bluntly: "The general topography of operant behavior is not important, because most if not all specific operants are conditioned. I suggest that the dynamic properties of operant behavior may be studied with a single reflex (or at least with only as many as are needed to assure the general applicability of the results). If this is true, there should be no incentive to 'botanize.' " p. 46f) Presumably, however, if it is not true, then there will be an incentive to botanize which is why we now find ourselves cutting through the botanical thicket of particular responses for particular species under particular circumstances. The law of effect has led us back to the problem of response topography via findings such as those reported here and their predecessors. Not too surprisingly, certain writers (*e.g.,* Seligman, 1970; Bolles, 1970; Staddon and Simmelhag, 1971; and Falk, 1971) have, in one way or another, called for full or partial repeal of the law of effect. But that may be premature, for the law of effect promises no more than to account for behavior in terms of its consequences (however conceived), which should never have been taken as a guarantee that the account must be simple or short, or even that we can really avoid the "thankless task" of botanizing behavior.

REFERENCES

Bolles, R. C. Species-specific defense reactions and avoidance learning. *Psychological Review,* 1970, **77,** 32-48.

Breland, K. and Breland, M. The misbehavior of organisms. *American Psychologist,* 1961, **16,** 681-684.

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.

Falk, J. L. The nature and determinants of adjunctive behavior. *Physiology and Behavior,* 1971, **6,** 577-588.

Rachlin, H. Autoshaping of keypecking in pigeons with negative reinforcement. *Journal of the Experimental Analysis of Behavior,* 1969, **12,** 521-531.

Rachlin, H. and Hineline, P. N. Training and maintenance of keypecking in the pigeon by negative reinforcement. *Science,* 1967, **157,** 954-955.

Segal, E. F. Induction and the provenance of operants. In R. M. Gilbert and J. R. Millenson (Eds.), *Reinforcement: behavioral analysis.* New York: Academic Press, (*in press*). Chapter 1.

Seligman, M. E. P. On the generality of the laws of learning. *Psychological Review,* 1970, **77,** 406-418.

Sidman, M. and Fletcher, F. G. A demonstration of auto-shaping with monkeys. *Journal of the Experimental Analysis of Behavior,* 1968, **11,** 307-309.

Skinner, B. F. *The behavior of organisms.* New York: Appleton-Century-Crofts, 1938.

Staddon, J. E. R. and Simmelhag, V. L. The superstition experiment: A reexamination of its implications for the principles of adaptive behavior. *Psychological Review,* 1971, **78,** 3-43.

Watson, J. B. *Behaviorism.* New York: People's Institute, 1924.

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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