*STIMULUS- AND RESPONSE-REINFORCER
CONTINGENCIES IN AUTOSHAPING,
OPERANT, CLASSICAL, AND OMISSION
TRAINING PROCEDURES IN RATS*

GILBERT W. ATNIP¹

THE OHIO STATE UNIVERSITY

Separate groups of rats received 500 trials of lever-press training under autoshaping (food delivery followed 10-second lever presentations, or occurred immediately following a response); operant conditioning (responding was necessary for food delivery); and classical conditioning (food followed lever presentations regardless of responding). Each group then received 500 trials on an omission procedure in which food was omitted on trials with a response. Another group received 1000 trials on the omission procedure, and a fifth group, random control, received 1000 uncorrelated presentations of lever and food. The autoshaping, operant, and classical groups reached high response levels by the end of initial training. Acquisition was fastest in the autoshaping group. Responding remained consistently low in the control group. The omission group responded at a level between the control group and the other three groups. During omission training, responding in these three groups declined to the omission-group level. During omission training, the rats continued contacting the lever frequently after lever pressing had declined. Response maintenance under omission training seems not to require topographic similarity between the response and reinforcer-elicited consummatory behaviors.

Key Words: Stimulus-reinforcer contingency, response-reinforcer contingency, autoshaping, operant conditioning, classical conditioning, omission training, lever press, rats

It is common practice to make a distinction between two procedures used in the study of conditioning. In the classical (respondent or Pavlovian) conditioning procedure, the experimenter arranges for the reinforcer (unconditioned stimulus) to occur at a specified time after the conditioned stimulus occurs. After training, the conditioned response, which resembles the response elicited by the reinforcer, begins to occur when the conditioned stimulus is presented. However, subsequent presentation of the reinforcer is not affected by the oc-

currence, or nonoccurrence, of this conditioned response. On the other hand, in the operant (or instrumental) conditioning procedure, occurrence of the reinforcer depends on the prior occurrence of a specified response, which does not necessarily resemble any reinforcer-elicited responses. The production of the reinforcer by the response may also be made conditional on the presence of a discriminative stimulus in the situation, and subjects will eventually come to respond only when that stimulus is present.

Many workers have attempted to show that there are differences between classical and operant conditioning that go beyond these procedural distinctions. One such proposal, which is closely tied to the procedures involved, is that the critical factor in the emergence and subsequent maintenance of the learned response is the conditioned stimulus-reinforcer contingency in classical conditioning and the response-reinforcer contingency in operant conditioning (Skinner, 1938). In a recent review, Hearst (1975) argued that none of the attempted distinctions between classical and operant conditioning has proved valid. He pointed out that Skinner himself has nullified

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the usefulness of his own distinction, noted above, by contending that contingency implies mere temporal contiguity (Skinner, 1948). By this definition, both types of contingencies are present in both types of conditioning, because both procedures consist of the temporal sequence of events: stimulus-response-reinforcer. Hearst suggested that, rather than continuing to pursue the classical-operant dichotomy, it might be more fruitful to investigate the relative contributions of both the stimulus- and the response-reinforcer contingencies to response generation and maintenance in a variety of experimental situations. This type of investigation was the primary goal of the work reported here.

Current interest in this type of study was stimulated by the work of Brown and Jenkins (1968) on the "autoshaping" of the pigeon's key peck. Two of their procedures are relevant here. In "forward pairing", the pigeon key was periodically illuminated, and if there was no response within 8 sec, food was delivered and the light went off; if a response did occur, food was delivered and the light went off immediately. This procedure explicitly specifies both a stimulus- and a response-reinforcer dependency. In the "fixed duration" procedure, the 8-sec illumination of the key was always followed by food delivery, and key pecks had no scheduled consequences. This might be called a classical conditioning procedure, as it explicitly specifies only a stimulus-reinforcer dependency. However, it also contains, implicitly, the possibility for a response-reinforcer "contingency", in Skinner's (1948) sense of temporal response-reinforcer contiguity. Brown and Jenkins found that both of these procedures effectively generated key pecking, and did not differ from each other in terms of the number of trials to the first response.

The importance of the stimulus-reinforcer contingency in the Brown and Jenkins procedures was established by Williams and Williams (1969). In order to eliminate the possibility of an adventitious response-reinforcer contingency, they employed the so-called omission procedure. In this procedure, food delivery followed the presentation of the keylight, unless a response occurred, in which case no food was delivered on that trial. Any responding, therefore, would have to be due solely to the stimulus-reinforcer contingency. Williams and Williams found that pigeons that acquired

the key peck under the forward-pairing procedure continued to peck on a substantial number of trials after being shifted to the omission procedure. They also found that birds eventually acquired the response when given the omission procedure from the beginning of training.

Ever since the work of Brown and Jenkins (1968) and Williams and Williams (1969), a number of studies have shown that both the forward-pairing and the fixed-duration (classical conditioning) procedures can generate and maintain a wide range of stimulus-directed responses, in a variety of species. These have included key pressing in monkeys and in children, key pecking in chicks and quail, and lever-contacting and lever-pressing behaviors in rats (see Hearst and Jenkins, 1974, for a review). However, a study by Gamzu and Schwam (1974) demonstrated that it is not safe to conclude that the stimulus-reinforcer relation was as influential in all these cases as it was in the case of the pigeon's key peck. Using the forward-pairing procedure, Gamzu and Schwam trained monkeys to press a lighted key, and then shifted them to the omission procedure. Responding virtually ceased after the shift, which indicates a negligible role for the stimulus-reinforcer contingency. Gamzu and Schwam proposed that the omission procedure be used to assess the role of the stimulus-reinforcer contingency in cases in which it appears that this contingency is influencing responding. Noting that the topography of the pigeon's autoshaped key peck closely resembles the topography of reinforcer-elicited consummatory behavior (Jenkins and Moore, 1973), while the topography of the monkey's key press does not, they predicted that responding would be maintained on the omission procedure only when the response resembled reinforcer-elicited consummatory behavior.

The present research focused on the effects of stimulus- and response-reinforcer contingencies on lever pressing in rats. As noted above, prior studies have found that rats began to contact a retractable lever when its presentation preceded food delivery, according to the classical conditioning procedure (Locurto, Terrace, and Gibbon, 1976; Peterson, Ackil, Frommer, and Hearst, 1972; Stiers and Silberberg, 1974). Rats also acquired and maintained contact responses under the omission procedure, though the level of responding was lower

than under the classical procedure, and response topography was different (sniffing and nosing on omission training, pawing and biting on classical conditioning). Following shifts from the classical to the omission procedure, frequency of contacts declined, but remained above control levels, and response topography shifted in the appropriate direction (Locurto *et al.*, 1976; Stiers and Silberberg, 1974). These findings indicate that both stimulus- and response-reinforcer contingencies influence lever-contact behaviors.

The above studies reported that lever presses occurred occasionally, but only one published experiment was directly concerned with lever pressing. Myer and Hull (1974) compared the efficacy of two procedures in the acquisition of this response. One was the forward-pairing procedure. The other was the operant conditioning procedure, in which a lever press had to occur in order for a reinforcer to be delivered on a trial. Both procedures produced rapid response acquisition, with no differences between them. Myer and Hull did not study classical conditioning and omission procedures, nor did they report any data on response topographies.

The first goal of the present study was to compare the forward pairing (hereafter called *autoshaping*), operant conditioning, classical conditioning, and omission procedures with each other, and with a random control procedure. The second goal was to evaluate the role of the stimulus-reinforcer contingency (and, by extension, that of the response-reinforcer contingency) in the *autoshaping*, operant, and classical procedures. This goal was approached by comparing responding on these procedures to that on the omission procedure during acquisition, and by observing the effects of shifting from these procedures to the omission procedure after acquisition. The third goal was to evaluate the proposition of Gamzu and Schwam (1974) that responding would be maintained on the omission procedure only if response topographies resembled the topography of reinforcer-elicited consummatory behavior. This goal was approached through detailed behavioral observations of subjects during omission training.

METHOD

Subjects

Thirty experimentally naive, male hooded rats, 90 to 120 days old at the beginning of

training, were divided into five groups of six subjects each, as described below.

Apparatus

All training took place in two identical chambers, both constructed of clear Plexiglas. These were in a sound-proofed room, separated from each other by a barrier. White noise was continuously present during all sessions. The interior dimensions of the chambers were 33 cm long by 22.5 cm wide by 32.2 cm deep. A Lehigh Valley Retractable Rodent Lever was mounted at one end of each chamber, equally distant from the side walls. When inserted into the chamber, the lever was 5 cm above the wire-mesh floor, and protruded 1.9 cm into the chamber. All depressions of the lever with a force of 0.10 N or more closed a microswitch and were recorded as lever presses. A food cup was located to the right of the lever such that the distance from its center to the center of the lever was 5.6 cm. Throughout the experiment, reinforcement consisted of the delivery of a single 45-mg Noyes pellet into the food cup by a Davis Scientific Instruments Company Pellet Dispenser, which made an audible click when it operated. Closed-circuit television cameras, located near the chambers, permitted observation of the rats' behaviors on monitors in a separate room. Also, a videotape recorder was used to record behaviors in selected sessions. Electromechanical equipment, located in the same room as the monitors, controlled experimental events and recorded data.

Procedure

Before the start of training, the rats were handled for 2 to 3 min daily, while their body weights were reduced to 80% of free-feeding levels. These weights, ± 15 g, were maintained throughout the experiment. In the first training session, adaptation was accomplished by leaving the rats in the apparatus for 1 hr, with the lever withdrawn, and 20 food pellets in the food cup. No other food was delivered during this session. Following adaptation, the study consisted of two phases.

Phase 1

A separate group of rats was placed on each of the following procedures. There were 10 days of training, with 50 trials per day. The intertrial interval was variable, with a mean of 40 sec.

Autoshaping: on each trial, the lever was inserted into the chamber. If there was no lever press within 10 sec, a reinforcer was delivered, and, concurrently, the lever was withdrawn. If there was a response, a reinforcer was delivered immediately, and the lever was withdrawn.

Operant: the procedure was the same as above, except that if there was no response during the trial, the lever withdrew and no food was delivered. That is, a lever press was necessary for reinforcer delivery on each trial.

Classical: on each trial, the lever was presented for 10 sec, followed by food delivery and lever withdrawal. Lever presses had no scheduled consequences.

Omission: the procedure was the same as classical, except that a lever press on a trial resulted in the immediate withdrawal of the lever and the omission of food on that trial.

Random control: lever and reinforcer presentations were arranged by independent tape timers, so that the probability of food delivery was equal in the presence and absence of the lever. Subjects received 50 of each type of event in each session. Lever presses resulted in the retraction of the lever, to provide a control for the possible reinforcing effects of the stimulus change involved in lever withdrawal *per se*.

Phase 2

This phase began the day after Phase 1 was completed. The autoshaping, operant, and classical groups received 10 days of training on the omission procedure described above. The omission and control groups received 10 additional days of training on the same procedures as in Phase 1. There were 50 trials per day, with a mean intertrial interval of 40 sec.

The experiment was conducted in three replications. An equal number of subjects from each group was trained in each chamber.

Observation Procedure

Before each session, 10 trials were selected for each subject by means of a random-number table. The subjects were observed on each of these trials by closed-circuit television. The type of lever-contact behavior exhibited by the rat was recorded on each observation trial. The following categories were used to classify contact behaviors: oral contact (rat touched lever with its mouth, either open or closed); paw contact; other contacts (included primarily sniffing and nosing lever, plus idiosyncratic to-

pographies, such as touching lever with dorsal surface of head). If there was no contact behavior on a given observation trial, the predominant behaviors that did occur were recorded, and observation was conducted on the next trial as well.

In addition to these direct observations, the behavior on these selected trials was videotaped so that a second, independent observer could later judge contact topographies. Technical problems with the videotaping system precluded recording any of the sessions involving Rats 1 and 2 in the autoshaping, operant, classical, and omission groups, and of some of the sessions involving Rats 3 and 4 in the same groups, as well as in the control group. In addition, because there was only one videotape recorder available, the behaviors of each subject were recorded only in alternating sessions.

Two independent judges served, at different times, to verify the behavioral observations. Both were aware of the general purposes of the experiment, but were kept unaware of the experimental conditions of the subjects they observed. Observer reliability was assessed separately for several observational categories. First, the proportion of observation trials on which the experimenter and the judge both observed some type of lever-contact behavior, regardless of specific topography, was found. This measure was 0.92 for the experimenter and judge 1, and 0.93 for the experimenter and judge 2. Next, a measure of agreement was calculated for each of the specific contact-topography categories. The total number of trials on which either the experimenter or the judge recorded an instance of a given category was found. Then, the number of trials on which both observers recorded that topography was found. Agreement was assessed by expressing the latter measure as a proportion of the former. The results were: oral contacts, 0.72 for experimenter and judge 1 and 0.74 for experimenter and judge 2; paw contacts, 0.93 for experimenter and judge 1 and 0.84 for experimenter and judge 2; other-type contacts, 0.80 for experimenter and judge 1 and 0.34 for experimenter and judge 2.

RESULTS

Table 1 gives the number of trials on which at least one lever press occurred, for all subjects in all groups, as well as the group medi-

ans on this measure, for each block of two sessions (100 trials). The distributions of scores presented in Table 1 did not meet the assumptions required for the use of the analysis of variance (Winer, 1971). In particular, there was radical departure from homogeneity of variance, both in the Phase 1 (between-subjects: $F_{\max} = 100.11$, $df = 5,15$, $p < 0.01$; within-subjects: $F_{\max} = 62.73$, $df = 5,15$, $p < 0.01$), and in the Phase 2 (between-subjects: $F_{\max} = 96.53$, $df = 5,15$, $p < 0.01$; within-subjects: $F_{\max} = 36.61$, $df = 5,15$, $p < 0.01$) data. Therefore, the Mann-Whitney U Test (Siegel, 1956) was used

to make between-group comparisons for each session block. Table 2 displays the results of this analysis by giving, for each comparison, the session blocks for which the obtained value of U was associated with a probability less than or equal to 0.05. The results are presented separately for Phases 1 and 2.

In Phase 1, acquisition of the lever press was most rapid in the autoshaping group. This group differed significantly from both the control and the omission groups throughout Phase 1, and from the operant and classical groups during the initial sessions of that phase. Inspec-

Table 1
Number of Trials with at Least One Lever Press in Each Block of Two Sessions (100 Trials)

Group & Subject	Phase 1 Blocks					Phase 2 Blocks				
	1	2	3	4	5	6	7	8	9	10
Autoshaping										
1	42	99	99	98	98	89	75	45	23	35
2	18	99	100	99	96	88	84	82	69	54
3	34	97	100	100	99	89	59	68	57	57
4	63	92	100	99	98	96	47	31	7	11
5	53	100	99	99	99	92	60	34	32	29
6	60	99	100	99	98	90	33	44	29	41
Median	51	99	100	99	98	89.5	59.5	44.5	30.5	38
Operant										
1	74	98	100	100	98	83	61	55	34	34
2	0	1	3	29	98	92	70	83	76	77
3	1	0	8	31	95	87	78	70	71	52
4	2	3	0	78	91	95	90	56	13	10
5	59	97	97	97	100	96	96	92	89	90
6	1	0	0	84	100	90	59	64	54	44
Median	1.5	2	5.5	81	98	91	74	67	62.5	48
Classical										
1	1	12	46	96	100	78	63	38	18	17
2	1	0	4	2	6	31	6	8	13	14
3	20	94	97	98	91	85	30	19	14	12
4	0	5	95	100	100	96	85	80	79	75
5	0	73	82	94	90	90	80	41	34	17
6	0	2	2	2	7	29	7	11	17	4
Median	0.5	8.5	64	95	90.5	81.5	46.5	28.5	17.5	15.5
Omission										
1	15	17	37	30	28	33	25	27	25	27
2	14	33	30	51	51	57	71	81	65	48
3	22	56	45	72	61	54	47	49	54	73
4	0	3	3	4	8	10	5	2	0	1
5	22	9	6	9	1	2	6	1	4	3
6	1	5	9	12	20	17	35	17	28	43
Median	14.5	13	19.5	21	24	25	30	22	21.5	35
Control										
1	1	4	6	3	1	0	3	0	0	0
2	9	3	4	3	4	2	2	2	0	0
3	11	5	11	7	9	9	4	6	1	1
4	0	1	0	1	0	2	1	1	1	3
5	5	0	6	16	13	5	14	11	3	3
6	1	1	0	1	1	0	0	0	1	1
Median	3	2	5	3	2.5	2	2.5	1.5	1	1

Table 2

Results of Mann-Whitney *U* tests: session blocks in which pairs of groups differed at 0.05 level.

	<i>Autoshaping</i>	<i>Operant</i>	<i>Classical</i>	<i>Omission</i>
PHASE 1				
Autoshaping		2, 3, 4	1, 2, 3	1, 2, 3, 4, 5
Operant			none	4, 5
Classical				(3, 4, 5)*
Control	1, 2, 3, 4, 5	4, 5	5	2, (3), 4, (5)
PHASE 2				
Autoshaping		none	none	6, 7
Operant			8	6, 7, 8
Classical				(6)*
Control	6, 7, 8, 9, 10	6, 7, 8, 9, 10	6, 7, 8, 9, 10	6, 7, (8), 9, 10

*Numbers in parentheses are results of analyses that did not include all subjects; excluded were classical 2 and 6, and omission 4 and 5. See text for elaboration.

tion of the individual data in Table 1 shows little between-subject variability in the autoshaping group: all rats responded on virtually every trial during the second through fifth session blocks.

Although acquisition of the response proceeded more slowly in the operant and classical groups than in the autoshaping group, the three groups did not differ by the end of Phase 1, at which point responding in all three was significantly greater than in the control and omission groups (see discussion of omission-group results below). There were no statistically significant differences between the operant and classical groups during acquisition. However, in terms of individual performances, the two treatments were not equivalent. Specifically, all six rats in the operant group ultimately pressed the lever on more than 90% of the trials, whereas only four of the six rats in the classical group did so. The other two classical subjects showed no evidence of response acquisition. It appears that the operant procedure was more reliable than the classical in producing acquisition of the lever press.

In general, the level of responding in the omission group fell between the level of the control group and that of the autoshaping, operant, and classical groups. The individual performances of the omission subjects were quite variable. Four rats eventually pressed on an intermediate percentage of the trials; the other two consistently responded on very few trials. This variability, particularly the low response levels in the latter two subjects, caused the results of some of the statistical comparisons involving the omission group to be somewhat deceptive. For example, the omission

group differed significantly from the control group in only six of the 10 session blocks when data from all subjects were included in the analysis. However, when the data from the two low-responding omission rats (4 and 5) were excluded, significant differences between the omission and control groups were found in three additional session blocks, indicated by the numbers enclosed in parentheses in Table 2. The problem of heterogeneity within treatment groups was even more marked in comparing the omission and classical groups, as both contained two low-responding subjects. The analyses which included all subjects showed no significant differences between these groups, yet an examination of both the group medians and the individual results strongly suggests that the two treatments did not have equivalent effects on those subjects that actually acquired the response (four in each group). Indeed, analyses that included only those subjects showed significant differences between the two groups during the session blocks enclosed in parentheses in Table 2.

During Phase 2, with the omission procedure in effect, responding declined in the autoshaping, operant, and classical groups. By the end of that phase, these groups did not differ from each other, or from the omission group, but did continue to respond at a higher level than the control group. The only significant difference among these three groups came in the eighth session block, when responding was greater in the operant group than in the classical.

Two aspects of the individual performances during Phase 2 are worth noting. First, there was considerable between-subject variability

within the autoshaping, operant, and classical groups. This finding was particularly striking for the autoshaping subjects, whose Phase 1 performances were quite homogeneous. Second, the shift to Phase 2 had a curious effect on the two classical subjects (2 and 6) that failed to acquire the response in Phase 1. Both of these rats showed a large increase in responding during the initial Phase 2 sessions, then both returned to their previous, low response levels.

Table 3 summarizes the data from the behavioral observations. In order to reduce the possible influence of observer bias, these data were derived solely from those observations on which both the experimenter and the independent judge were in agreement. Furthermore, the data were taken only from sessions during which the omission procedure was in effect. Those sessions that contributed to the data for each subject are specified in the table. The focus was on these sessions because the primary purpose of making the observations was to assess the relation between contact topography, especially oral contacts, and the maintenance of responding on the omission procedure. Table 3 presents three measures relevant to this purpose: the ratio of the number of observation trials on which at least one lever-contact behavior was observed to the total number of observation trials; the number of observation trials on which at least one instance of an oral lever-contact behavior was observed; the number of trials on which at least one lever press occurred. The table gives, for each subject, the sum of each of these measures over all the specified sessions, and the total obtained on each measure in the final observation session only.

The proposition of Gamzu and Schwam (1974) that maintenance of a high level of responding on the omission procedure is accompanied by response topographies that are related to reinforcer-elicited consummatory behavior leads to the prediction that subjects with frequent oral contacts should also show frequent lever presses. That is, there should be a positive correlation between the number of trials with an observed oral contact and the number with a lever press. A Spearman rank-order correlation between the sums across sessions on these two measures, given in Table 3, yielded a correlation coefficient of 0.26, which is not statistically significant. In the last obser-

vation session, the correlation between the two variables was also nonsignificant ($r_s = 0.05$).

The basis for these nonsignificant correlations can be seen in the individual data. In particular, some animals made few oral contacts and many lever presses (*i.e.*, autoshaping 4 and 5; operant 4; classical 5; omission 3 and 6), and animals that made many oral contacts and few lever presses (*i.e.*, classical 3 and 6). In short, the degree to which a subject made oral lever contacts was not a reliable predictor of the degree to which that subject pressed the lever.

In fact, the data in Table 3 reveal that the degree to which a subject contacted the lever, regardless of contact topography, was not a very good predictor of the degree of that subject's lever pressing, at least during the sessions when the omission procedure was in effect. The correlation between the proportion of observation trials with an observed contact, and the proportion of lever-presentation trials with a lever press over all observation sessions was not significant ($r_s = 0.36$, $p > 0.05$). The same correlation, for the last session only, was even smaller ($r_s = 0.17$, $p > 0.05$).

The lack of a strong relationship between lever contacting and lever pressing was due, in large part, to the fact that the subjects tended to contact the lever while not pressing it. The proportion of observation trials with a lever contact was greater than the proportion of lever-presentation trials with a lever press for all 16 subjects, both for the data taken over all observation sessions, and for those in the last session only. The magnitude of the difference was especially marked in the last session. For that session, the differences between the mean proportion of observation trials with a lever contact and the mean proportion of lever-presentation trials with a lever press, for the various groups, were: autoshaping, 0.59; operant, 0.40; classical, 0.58; omission, 0.53. In general, then, the omission procedure resulted in a moderate amount of lever pressing and a high amount of lever-contact behavior.

DISCUSSION

The first goal of this research was to compare the experimental procedures employed in the acquisition of the lever press. The results were clear: the response was acquired to the same, high terminal level in the autoshaping, oper-

Table 3

Summary of confirmed observational data (groups abbreviated as follows: Autoshaping, AS; Operant, OC; Classical, CC; Omission, OT.)

<i>Group & Subject</i>	<i>Sessions</i>	<i>Contact Trials/ Observed Trials</i>	<i>Oral Contact Trials</i>	<i>Lever-Press Trials</i>
AS 3	15, 17,			
	19, & 21	39/41	26	120
	21	10/10	8	26
AS 4	16, 18, 20	30/31	2	31
	20	10/10	0	5
AS 5	12, 14, 16,			
	18, & 20	43/67	9	112
	20	9/15	1	15
AS 6	13, 15, 17,			
	19, & 21	49/53	24	111
	21	10/10	8	16
OC 3	15, 17,			
	19, & 21	39/41	32	121
	21	10/10	9	19
OC 4	16, 18, 20	30/33	9	47
	20	10/11	1	7
OC 5	12, 14, 16,			
	18, & 20	50/53	27	120
	20	10/10	3	45
OC 6	13, 15, 17,			
	19, & 21	47/59	20	162
	21	10/13	2	28
CC 3	15, 17,			
	19, & 21	39/46	31	36
	21	10/12	9	9
CC 4	16, 18, 20	30/31	5	115
	20	10/10	1	35
CC 5	13, 15, 17,			
	19, & 21	50/51	40	135
	21	10/10	9	11
CC 6	12, 14, 16,			
	18, & 20	50/51	43	27
	20	10/10	10	1
OT 3	3, 14, 16,			
	18, & 20	45/60	1	123
	20	10/12	0	32
OT 4	2, 4, 15, 17,			
	19, & 21	51/72	3	4
	21	9/10	1	1
OT 5	2, 4, 6, 8,			
	10, 12, 14,			
	16, 18, & 20	54/184	0	36
OT 6	20	9/19	0	1
	3, 5, 7, 9,			
	11, 13, 15,			
	17, 19, & 21	91/118	6	82
	21	10/12	1	12

ant, and classical procedures, but acquisition was fastest and most consistent between subjects in the autoshaping group. The operant and classical procedures did not differ in over-

all terms, but in individual-subject terms, the operant procedure might be considered superior, in that it yielded acquisition in all six subjects, *versus* acquisition in only four of six

subjects in the classical procedure. The omission procedure also produced acquisition in only four of six rats, and the group-median response level was lower than in the above three groups. Finally, the random control procedure produced very little responding throughout the experiment.

The finding of more rapid acquisition in the autoshaping than in the operant procedure disagrees with the results of Myer and Hull (1974), who found no differences between the two procedures. The most plausible interpretation of this discrepancy is related to the second, and major, goal of the present study, which was to analyze the relative contributions to responding of both the stimulus-reinforcer and the response-reinforcer contingencies in the autoshaping, operant, and classical procedures. The autoshaping procedure contained an explicit stimulus-reinforcer contingency, such that, early in training, reinforcers followed lever presentations on trials on which no responses occurred. The operant procedure contained no such contingency: no reinforcers were ever delivered unless a response was made. If the emergence of the initial responses in the operant procedure was due solely to the operation of "nonassociative" factors, such as the salience of the lever, its proximity to the food cup, and the subject's general activity (*cf.* operant-level responses), the speed of acquisition in that procedure should have depended on the degree to which conditions were conducive to the operation of such factors. On the other hand, if the initial responses in the autoshaping procedure arose primarily from the stimulus-reinforcer contingency, with some contribution from nonassociative factors, the speed of acquisition should not have depended so much on the operation of such factors. An assessment of the contribution of nonassociative factors can be made from the results of the random control procedure. Responding on this procedure was low in the present study, but was moderately high in the Myer and Hull study. By the reasoning above, acquisition on the operant procedure should have been faster in the Myer and Hull experiment than in this one, and such was indeed the case. By the same reasoning, there should have been little difference in acquisition speed on the autoshaping procedure, and in fact, both studies found such acquisition to be rapid. The stimulus-reinforcer contingency, then, contributed sig-

nificantly to response acquisition in the autoshaping group. The response-reinforcer contingency was also important, though. This fact is indicated by the superiority of the autoshaping over the classical conditioning group early in training. These groups differed, of course, in that the classical procedure did not contain an explicit response-reinforcer contingency, while the autoshaping procedure did.

The lack of an explicit response-reinforcer contingency in the classical procedure would seem to suggest that responding in that group was produced solely by the stimulus-reinforcer contingency. However, it is also possible that an adventitious response-reinforcer contingency was operating, because early lever presses may have been closely followed by food. On the other hand, two subjects in this group did not acquire a high level of responding, even though they did press the lever occasionally. These presses should have allowed any adventitious contingency to take effect and generate further responses. The fact that it did not do so argues that, in the classical procedure, the stimulus-reinforcer contingency generated lever contacts that happened to produce lever presses in some, but not all, of the subjects (*cf.* Locurto *et al.*, 1976; Peterson *et al.*, 1972; Stiers and Silberberg, 1974).

It is likely that once responding was acquired, it was maintained in both the autoshaping and the operant procedures by the joint action of the stimulus- and response-reinforcer contingencies. This conclusion is based on the outcome of Phase 2, in which the subjects in these groups were shifted to the omission procedure. Responding declined after the shift, which indicates its sensitivity to the response-reinforcer contingency. However, it did not decline to control levels, but rather to the omission-group level, which indicates its sensitivity to the stimulus-reinforcer contingency as well.

Responding also declined during Phase 2 in those classical conditioning subjects that had acquired the lever press in Phase 1. This finding could be interpreted as evidence for the operation of an adventitious response-reinforcer contingency during Phase 1, but there are reasons for doubting such an interpretation (see above). The response decline could have been due to a suppressing effect of the negative response-reinforcer contingency of the omis-

sion procedure. There is no reason that behavior that is originally generated and maintained by a stimulus-reinforcer contingency should be totally insensitive to a response-reinforcer contingency when one is imposed. The decline in responding could also have been due to the decline in the percentage of reinforced trials that followed the shift to the omission procedure (Ross, 1959). The present results do not permit any meaningful analysis of the contribution of these factors to the Phase 2 response decline in the classical group.

The third goal of this research was to evaluate the role of the relationship between the topography of the acquired response and that of reinforcer-elicited consummatory responses in the maintenance of responding under the omission procedure. Of particular interest was the hypothesis of Gamzu and Schwam (1974), that responding would be maintained only when the response was similar to reinforcer-elicited consummatory behaviors. The present results do not seem to support this hypothesis. Rather, it appears that the maintenance of responding during omission training does not require that the response be related topographically to behaviors elicited by the reinforcer.

While the behavioral observations did not yield a relationship between contact topography and response maintenance, they did produce some interesting data on lever-contact behavior under the omission procedure. Every subject observed showed a higher proportion of lever-contact trials than lever-press trials. Even at the end of Phase 2, after hundreds of omission-training trials, most rats were still contacting the lever on a high proportion of the observation trials, regardless of their lever-pressing behavior.

Why did the rats continue to contact the lever when lever presses omitted the reinforcer? The present data do not supply any real answer to this question. It is tempting to ascribe contact maintenance to the stimulus-reinforcer contingency. This must be the case for contacts that produced presses, if the logic of the omission-training assessment procedure is valid. Nonpressing contacts, however, were not subject to the omission contingency, so there is the possibility that they were partially maintained by adventitious reinforcement. On the other hand, it is not clear *a priori* why adventitious reinforcement should maintain

lever contacts, rather than some type of non-contact response.

One way to approach this problem would be to apply the omission contingency to lever contacts. Previous work suggests that the result would be a decline in contacts (Locurto *et al.*, 1976; Stiers and Silberberg, 1974). It might then prove interesting to measure approaches to the lever and if such behaviors persisted, to apply the omission contingency to them as well (*cf.* Wasserman, Franklin, and Hearst, 1974). This approach to understanding the controlling variables of the terminal response by analyzing the sequence of behaviors leading up to it will probably become increasingly refined and important as research on these complex issues continues.

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