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GROVES, Lee Canipe, 1947-
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ON AUTOMAINTENANCE IN THE PIGEON.

University of North Carolina at Greensboro,
Ph.D., 1974
Psychology, general

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THE EFFECTS OF TRIAL AND CYCLE DURATIONS ON AUTOMAINTENANCE IN THE PIGEON

by

Lee Canipe Groves

A Dissertation Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Greensboro
1974

Approved by

Aaron J. Brownstein
Dissertation Adviser

APPROVAL PAGE

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GROVES, LEE CANIPE. The Effects of Trial and Cycle Durations on Automaintenance in the Pigeon. (1974)
Directed by: Dr. Aaron J. Brownstein. Pp. 180.

Thirty-six naive pigeons were assigned to groups which differed with respect to trial duration (6, 12, 24, 30, 48, or 96 sec), cycle duration (30, 60, or 120 sec), and, consequently, with respect to the ratio of trial to cycle (.20, .40, .80, or 1.00). All groups were magazine trained, then exposed to a negative-contingency autoshaping procedure modeled after the Williams and Williams (1969) design, except that the trial and cycle durations were specific to each group. Specifically, each subject was placed in a standard operant conditioning chamber illuminated only with an overhead houselight. Periodically (at intervals determined by the cycle duration for each group), a response key was transilluminated for a time specified by the trial duration for the respective groups. If no response occurred to the lighted key, a filled and illuminated grain hopper was presented at the termination of the keylight. If the bird pecked at the key, the key was darkened, the remainder of the trial period was indicated by overhead green illumination, and no grain was presented.

On several dependent measures (number of keylight-grain pairings prior to the first response, number of cumulated sec of trial time prior to the first response, percentage of trials containing a response over the first ten days, maximum responding reached over the first ten days,

and number of sessions on which responding was maintained at equal to or greater than 10% of the trials), it was found that keypecking was more likely to be acquired, was acquired more rapidly, and was maintained longer, the smaller the ratio of trial to cycle. The absolute trial and cycle values were seen to exert some influence, however, in that any given ratio value was more effective by these criteria the smaller the absolute values of the trial and cycle. These group data were confirmed by individual manipulations in which each subject was exposed to a series of trial to cycle ratio values within the context of a constant cycle duration. Keypecking was not successfully educed in subjects which were begun on high ratios (which were ineffective in educing responding), but responding in birds which had been initially exposed to low ratios was successfully manipulated up and down over five to six reversals merely by changing the ratio of trial to cycle.

These results were repeated with nine pigeons exposed to a fixed-trials autoshaping procedure in which there was no contingency between keypecking and grain presentation. Group and individual data supported the effect of ratio of trial to cycle as a major determinant of acquisition and maintenance of pecking, with additional influence again being seen by the specific value of the trial and cycle duration.

These results were discussed within the context of other autoshaping data, as well as within the context of current reformulations of the concept of "reinforcement," in which stimuli are viewed as playing both "reinforcing" and "eliciting" roles within any given behavioral context.

ACKNOWLEDGMENTS

Sincere appreciation is expressed to the members of my Doctoral Committee, Dr. Robert Eason, Dr. Richard Shull, Dr. Kendon Smith, and Dr. Thomas Smythe. Particular thanks go to Dr. Aaron J. Brownstein, Major Professor, for his invaluable guidance throughout not only the dissertation, but also my graduate years. Appreciation is also expressed to Dr. Evelyn Segal for her support and advice, and to my husband Ivor for his advice and assistance with the study.

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INTRODUCTION

> In the experimental analysis of behavior many species differences are minimized. Stimuli are chosen to which the species under investigation can respond and which do not elicit or release disrupting responses . . . . In this way species differences in sensory equipment, in effector systems, in susceptibility to reinforcement; and in possible disruptive repertoires are minimized (Skinner, 1966, p. 1210).

In accord with the above assumptions, the majority of operant studies to this date have examined the effects of various manipulations on the rate (for example) at which the laboratory pigeon pecks an illuminated disc. This keypecking response, then, is considered to be "operant" behavior, so defined by its increase in strength consequent to the presentation of a reinforcing stimulus (for an elaborated definition of "operants" and "conditioning of type R," see Skinner, 1938, pp. 1-43).

It has therefore been the dependency (contingency) relationship between the pecking response and the presentation of a reinforcing stimulus (such as grain) to which credit for the acquisition and maintenance of the response has been given. Recently it has been reported, however, that keypecking can be reliably established in the pigeon even when explicit response-reinforcer contingencies are not programmed (Brown and Jenkins, 1968). In the Brown and Jenkins procedure, to which they refer as an "auto-shaping" procedure, 8-sec presentations of a lighted response key are followed at the offset by 4-sec periods of access to a lighted grain hopper. When magazine-trained, but otherwise experimentally naive, pigeons were exposed to this procedure, 36 out of 36 subjects came to make a response on the lighted key, within an average of 45 pairing trials. Control conditions indicated that it was the pairing of the lighted key with food, rather than generalization from hopper-directed pecking or reinforcement by presentation of either the lighted key alone or the grain alone, which was responsible for acquisition of the pecking response. Brown and Jenkins interpreted their results in terms of a superstition of the "third" type, in which reinforcement is conditional on the stimulus change, but not on responding on the part of the organism (see Skinner [1948], and Morse and Skinner [1957], for superstitions of the first and second types). The bird "notices" the keylight, and this noticing is adventitiously correlated with reinforcement. The adventitious reinforcement of noticing leads to orienting and pecking at the key. The species-specific tendency of the pigeon to peck at the things it looks at accounts for the shaping of the pecking response rather than some less-effortful precursor to the keypeck. Brown and Jenkins also mentioned the similarity of the procedure to the respondent domain, but retained their "shaping" explanation because the response appeared to "grow out of" motor activity in the vicinity of the key rather than emerge as a full-blown "reflex."

Rapidly following the report by Brown and Jenkins have come a number of studies which suggest that the autoshaping phenomenon is not limited to the laboratory pigeon. Autoshaping studies of designs similar to that of Brown and Jenkins have reported the successful "shaping" of a number of different organisms: rhesus monkeys (Sidman and Fletcher, 1968), bobwhite quail (Gardner, 1969), retarded children (Watson, 1971), retarded adults (Quattlebaum, 1971), rats (Smith et al., 1971), and dogs (Smith and Smith, 1972). Few appropriate control conditions have been run in these species replications; thus it has not been demonstrated that the same variables are operable as those which produce responding in the laboratory pigeon. It does appear, however, that the procedure itself is useful in rapidly establishing responding to a specific manipulandum in a number of species.

Williams and Williams (1969) felt that the consistency of the results obtained by Brown and Jenkins (1968) suggested that adventitious reinforcement was too "haphazard" a process to serve as an explanation of the acquisition of the pecking response. They therefore devised a procedure, adapted from Sheffield's (1965) "omission" training design, in which the adventitious reinforcement of the keypeck was circumvented. The procedure was similar to that of Brown and Jenkins, except that the "free" reinforcement was presented at the termination of the trial stimulus only if no responding occurred during the presentation of the trial light. If a response occurred on the lighted key, the key was immediately darkened and no reinforcer was presented. Under these conditions, Williams and Williams found that responding was maintained at "substantial" rates. Only one subject responded on less than 10% of the daily trials once pecking had begun. The Williamses called their procedure a "negative contingency," and their results "automaintenance," (from here on to be referred to as "negative automaintenance," to distinguish maintained responding under the negative contingency from responding observed under the various "positive" autoshaping procedures).

The keypeck has long been considered a skeletal, emitted, "operant" response; a response under the control of its consequences. Indeed, it has served as the "prototype" of the operant response, much as the salivary response has served as the prototype of elicited, involuntary behavior (the reflex or respondent). Yet here we have the persistence of the keypecking response even though it serves only to cancel the presentation of a stimulus which has repeatedly been shown to be a reinforcing one for a food-deprived pigeon. The phenomenon of negative automaintenance apparently represents an enigma for outcome-contingent control and modification of behavior. The response cannot be obviously reinforced even adventitiously, as a reinforcement is never allowed to follow a pecking response which is effective in closing the microswitch.

Both Williams and Williams (1969) and Brown and Jenkins (1968) pointed out the similarity of their design to those in the respondent domain. In a "positive" trials procedure like that of Brown and Jenkins, the keylight is paired with the presentation of grain in the standard forward-pairing procedure of classical or Pavlovian conditioning. Through a process of "stimulus substitution," the response (pecking) originally elicited by the unconditioned stimulus (grain) eventually could come to be elicited by the previously neutral conditioned stimulus (lighted key). Brown and Jenkins did not think that classical conditioning was a likely explanation because the pecking response, upon observation, appeared to "grow out" of early motor responses in the vicinity of the key. Williams and Williams, while feeling that their negative-contingency data had ruled out an explanation of the acquisition of the response solely in terms of adventitious reinforcement, also pointed out some difficulties with an explanation couched in the framework of classical or respondent conditioning. In the first place, a response such as pecking (one which appears to "operate" actively on the environment) has not traditionally been viewed as amenable to conditioning in the respondent sense. Also, no principles thus far derived from the study of classical conditioning explain why the autoshaped response is "directed" toward any specific portion of the environment.

Williams and Williams concluded that neither operant nor respondent principles can readily account for these negative-automaintenance data, and they compared their findings to earlier data reported by Breland and Breland (1961) on "instinctive drift," in which "counterproductive" behavior (which appeared to be related to the natural "food-getting" behavior of the organism in question) emerged to the detriment of reinforcement, after continued exposure to the experimental situation.

A number of further studies have attempted to clarify the respective roles of operant and respondent conditioning. Gamzu and Williams (1971) employed a procedure adapted from one used by Rescorla (1967) to illustrate a contingency (as opposed to pairing) model of classical conditioning. They reported that, as with classical conditioning, the light-food pairings did not have to occur on a one-to-one basis, but that the keylight merely had to be differentially associated with the presentation of grain. They found pecking at high rates on a "differential" condition (in which grain was presented with a certain probability in the presence of the keylight, and only in the presence of the keylight) to decrease rapidly and drastically when the birds were then moved to a "non-differential" condition in which grain was presented with the same probability in the absence of the keylight as in its presence. Interestingly, rates on the differential condition which followed exposure to a non-differential condition were never as high as on a differential condition which was the birds' first exposure to the experimental situation.

Gamzu (1971) offered an explanation for this non-reversibility in going from a non-differential to a differential condition. After running the additional groups of *no-reinforcement* (reinforcement was presented neither in the presence nor absence of the lighted key), and *explicit-inhibitory* (reinforcement was presented only in the absence of the keylight), he concluded that when the differential condition followed a condition in which reinforcement was delivered but pecking not "educed," subsequent rates would be low. This conclusion was based on an hypothesized interaction between two processes: (1) direct stimulus-stimulus effects (when the lighted key and food are paired, pecking is elicited or "educed" in some kind of classical conditioning effect), and (2) reinforcement (adventitiously) of the behavior which immediately preceded the delivery of grain. If the initial exposure to reinforcement (meaning here, food delivery to a hungry pigeon) is in a situation in which pecking will be educed, adventitious reinforcement of the pecking response establishes a positive-feedback loop which serves to increase the rate of keypecking. If reinforcement is presented when pecking is not educed, however, some <u>other</u> behavior than pecking will be adventitiously reinforced, and it will subsequently interfere with the establishment of a positive-feedback loop in a situation in which pecking <u>is</u> educed. In the negative-contingency procedure, then, responding should be educed by the pairing of the keylight with food on trials on which a response does not occur, but the response itself cannot be adventitiously reinforced, so a low rate of pecking should be observed.

All of the studies reviewed thus far indicate the importance of the stimulus-stimulus relationship in the production of the autoshaped pecking response. It seems clear that an account of the negative-contingency responding will require more information regarding the important parameters of the relationship between the trial stimulus and the delivery of the filled grain hopper. If the trial stimulus (lighted key) functions as some sort of conditioned or "releasing" stimulus for the consummatory pecking response, then several aspects of the keylight-grain relationship might contribute to the determination of how much responding is directed toward the key. As mentioned above, Gamzu and Williams (1971) have demonstrated that the keylight and grain need not be paired on a one-to-one basis in order for pecking to be observed, but that pecking is still reliably directed toward the key if the keylight merely accompanies a condition in which grain is occasionally presented with a higher probability than the probability of its presentation in the absence of the keylight. In their study the probability of grain at any given second in the absence of the keylight was zero, while the probability in the presence of the lighted key rose to .03 at the start of each second. The boundary conditions and range of values of probability over which this relationship holds remains to be delineated. These results in terms of differential probability are in line, of course, with Rescorla's (1967) contingency viewpoint of the important relationship of classical conditioning.

One end of such a contingency continuum is that of a one-to-one relationship: the keylight predicts perfectly the forthcoming delivery of grain. This is, of course, the condition under which most of the automaintenance studies have been conducted. Even given that the trial stimulus (CS) predicts grain delivery 100% of the time, however, there are other properties of the stimulus of possible importance. For example, if the stimulus is considered as a conveyor of information, either in the sense of a predictive cue of forthcoming events or in the sense of a clue as to what behavior in which to engage (Hendry, 1969), amount of information can still vary. Given that the stimulus signals forthcoming grain, how imminent is its delivery?

In this sense, the absolute duration of the trial stimulus may be relevant, as well as the absolute duration of the period between reinforcements, and the relative proportion of the total cycle (trial stimulus plus intertrial interval) which the trial stimulus occupies.

Jenkins (1970), in offering an explanation for the fact that certain groupings of non-reinforced and reinforced trials in a sequence resulted in more responding to the non-reinforced trials than did certain other groupings, remarks:

> When reinforced trials occur only after long intervals, as they do in the spacing of NR-NR, an antecedent non-reinforced trial anticipates the arrival of reinforcement . . . An especially strong anticipatory signal might be expected to generate an especially high degree of excitement and more vigorous responding. The conditioning of excitement would be governed by response-independent or 'classical' pairings of the N-trial stimulus with subsequent reinforcement (1970, p. 90).

In the discrete-trials paradigm referred to by Jenkins (above), in which brief, non-reinforced trial stimuli closely precede the availability of reinforcement on another trial, the first trial stimulus can be seen as analogous to the trial stimulus in the autoshaping procedure.

There are two parameters to examine here: (1) absolute duration of the trial stimulus and (2) absolute duration of the total cycle. In addition, a third aspect of the experimental situation, relative proportion of the total cycle which is occupied by the trial stimulus, will vary with the values set for the trial and cycle. With reference to the first parameter, one might ask if a five-sec trial stimulus would be more effective than a ten-sec stimulus simply because the onset of the five-sec stimulus is closer in time to the delivery of grain. On the other hand, the ten-sec stimulus might be more effective than the five-sec stimulus simply in terms of duration of availability. Only a few trial values have been examined thus far in the pigeon, and these values have been relatively homogeneous: 8 sec (Brown and Jenkins, 1968), 6 sec (Williams and Williams, 1969), 8.6 sec (Gamzu and Williams, 1971), and 7.5 sec (Brownstein and Groves, 1971). In one procedure, using non-fixed trials and positive autoshaping, Brown and Jenkins did compare acquisition of the first pecking response under a 3-sec trial-stimulus condition with that under an 8-sec trial-stimulus condition, and found no outstanding differences either with respect to the number of subjects which autoshaped or to the rapidity of acquisition. This comparison study was only in effect for a period of 160 pairings, however, so the effects on the maintenance of the response were not examined.

In terms of a view of the trial stimulus as an anticipatory signal for the forthcoming delivery of grain, it seems reasonable that the effectiveness of any given trial value would also depend upon the relation of the duration of the trial to the overall duration of the interval between reinforcements. It has already been demonstrated

(Brown and Jenkins, 1968) that the keylight cannot be lighted 100% of the time if pecking is to be established. In the informational context, this is only reasonable, as a stimulus which is continuously present is in no way uniquely associated with the delivery of grain, and should therefore be expected to be no better signal than any other portion of the immediate surround. The smaller the ratio of the duration of the trial stimulus to the duration of the cycle, then, the more important the role of the trial stimulus as a signal for grain. For example, an 8-sec trial stimulus would be expected to be better than a 30-sec stimulus relative to an overall cycle of 60 sec. That same 30-sec stimulus, however, when relative to a cycle of 300 sec, might be a better signal than an 8-sec stimulus relative to an overall cycle of only 16 sec.

The length of the cycle itself might influence responding. If food is being delivered very often, with only brief periods between reinforcements, the role of a signalling stimulus might be inconsequential. On the other hand, if the interval between reinforcements is extremely long, there may be so little expectation of food in the situation that the signal would again be unimportant.

The present experiment was designed to test some of these expectations. The basic design involved running a number of trial-stimulus values in combination with a number of overall cycle values. This made possible the evaluation of the effect of the absolute duration of the trial stimulus, absolute duration of the overall cycle, and the relative duration of the trial stimulus. An initial study was run under a negative-contingency design similar to that reported by Williams and Williams (1969). Under a negative contingency, the "elicitation" effect of the pairing trials can be more easily examined than in a positive-autoshaping procedure, because the negative response contingency prevents the adventitious reinforcement of the pecking response. The responding under comparable stimulus values with a positive-trials procedure is also important in itself, however, so positive trials were run in a later part of the experiment.

Because evidence suggests that the negative-automaintenance phenomenon is partially irreversible (performance changes with continued exposure; birds in this laboratory have been observed to consistently move "off" the key and peck at some idiosyncratic location within the experimental chamber), a group design was employed rather than the repeated measurement of some smaller number of subjects. When circumstances permitted (when a bird had maintained pecking behavior on the key for several days, or when he had never begun a high percentage of pecking), however, the treatment condition was shifted in an attempt to manipulate keypecking for individual subjects.

METHOD

Experiment I

Subjects

Twenty-four White King and twelve Silver King pigeons, all experimentally naive at the outset of the experiment, served. Birds were maintained at approximately 80% of their free-feeding weights by daily feeding with Purina pigeon grains. When a bird did not receive enough grain in the experimental chamber to maintain 80% body weight, additional grain was given in the home cage immediately after the daily session. Water and grit were available in the home cage.

Apparatus

The experimental chamber was a standard Lehigh Valley two-key pigeon chamber, 30 cm by 35 cm by 40 cm. The houselight fixture used miniature bayonet bulb #1829, was deflected, and was shielded by brown paper (to increase the contrast effect of the illuminated trial light). When the grain hopper, centered on the response panel 7.5 cm above the floor of the chamber, operated it was illuminated by two #1829 miniature bayonet bulbs. The left response key was shielded with black tape for the duration of the experiment. The right response key could be transilluminated simultaneously with three Sylvania 28V bulbs, unshielded. Three green jewel lamps, also using #1829 miniature bayonet bulbs, were mounted on the top left-hand corner of the response panel, and could be illuminated simultaneously.

Procedure

Subjects were assigned to one of nine negative-contingency conditions, as indicated in Table 1, by drawing band numbers from a box. After magazine training, all birds were placed directly on the negative contingency. Eighteen birds were run daily for 50 trials. Trial and cycle values were chosen in such a way that absolute and relative trial values could be compared and examined across groups.

Magazine training: This stage of training was kept as uniform as possible for all birds. Upon the bird's initial placement in the chamber, only the houselight was lighted. The hopper was then raised until the bird had eaten steadily for approximately 20 sec. Over the next few hopper presentations, eating time was gradually reduced to 4 sec. A total of 20-25 magazine feedings was presented to each bird on the first day. The presentations were made without respect to the bird's behavior, except for the first few (which were made when the bird was facing the hopper) and the last few (which were to determine if the bird would

TABLE 1

Nine Initial Treatment Conditions Under a Negative Response Contingency

SUBJECT	TRIAL	CYCLE	TRIAL/CYCLE
A1 - A4	6 sec	30 sec	.20
B1 - B4	12 sec	30 sec	.40
C1 - C4	24 sec	30 sec	.80
D1 - D4	30 sec	30 sec	1.00
E1 - E4	12 sec	60 sec	.20
F1 - F4	24 sec	60 sec	.40
G1 - G4	24 sec	120 sec	.20
H1 - H4	48 sec	120 sec	.40
I1 - I4	96 sec	120 sec	.80

approach the hopper from anywhere within the chamber). On the second day, 10-15 magazines were presented to insure that training was accomplished; each bird was then immediately placed on its respective treatment condition.

Negative contingency: Trials consisted of the illumination of the response key for the specified period, after which the keylight and houselight were turned off and a 4-sec access to grain was permitted. Trials were separated by fixed intertrial intervals, again specific to each group. If a peck was made to the lighted key, houselight and keylight were both terminated immediately, and the green jewel lamps were transilluminated for the remainder of the trial period (to differentiate the remainder of the aborted trial from the beginning of the next cycle, an attempt to keep the cycle "fixed"). These jewel lamps also remained on during the 4 sec which would have been allotted to hopper time had no responding occurred during the trial. These stimulus and response relationships are diagrammed in section (C) of Figure 1, which also includes a representation of Brown and Jenkins' (1968) original "positive" autoshaping procedure (1A), and Williams and Williams' (1969) negative contingency with a variable intertrial interval (1B).

Pre-trial pecks (during the intertrial period) and post-trial pecks (when a trial was cancelled) were recorded but had no programmed consequences (few of these

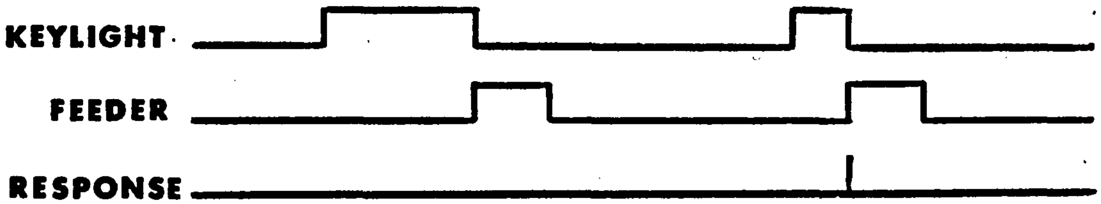
Figure 1. Four autoshaping procedures:

(A) positive-trials design used by Brown and Jenkins (1968);

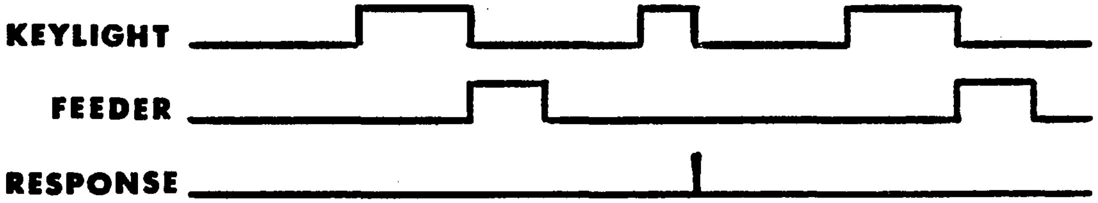
(B) Williams and Williams' (1969) original negative contingency;

(C) negative-contingency used in Experiment I;

(D) positive fixed-trials design used in Experiment II.


KEYLIGHT
FEEDER
RESPONSE

(A)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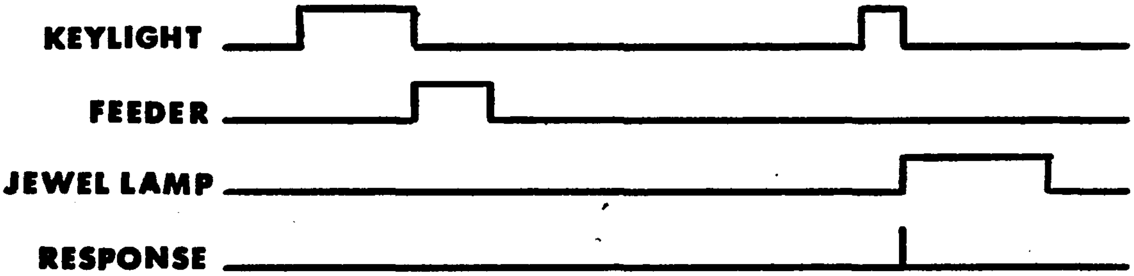
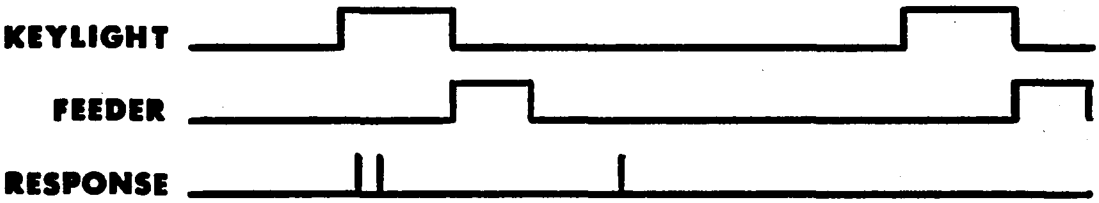
FEEDER
RESPONSE

(B)


KEYLIGHT
FEEDER
JEWEL LAMP
RESPONSE

(C)


KEYLIGHT
FEEDER
RESPONSE

(D)

responses occurred in the negative condition). Also recorded on counters were number of trials, number of trial responses, and number of reinforcements received. A print-out record was kept of the latency of response from the initiation of the trial. The trial number of the first response of the session was also recorded.

Individual manipulations: When responding appeared to have stabilized on the initial condition (or when pecking had not been acquired on the initial condition after several weeks exposure), the treatment trial/cycle ratios for each subject were manipulated in an attempt to either increase or decrease responding to the trial stimulus. For some of these subjects these manipulations had little or no effect. For about one-third of them, however, some degree of success in manipulating responding was achieved. These subjects were carried through several reversals, which are indicated in Table 2.

Experiment II

Subjects

Six White King and three Silver King pigeons served. Six of the birds were experimentally naive and two (P-7 and P-8) had served for four days on a negative-contingency autoshaping study, and one (C-3) had served throughout the preceding negative-contingency study. All were maintained at 80% of their free-feeding weights.

TABLE 2

Data Summary for Individual Manipulations on Negative Automaintenance

	B-1				
TRIAL/CYCLE	.40	.10	.40	1.0	.10
TRIAL (SEC)	12	3	12	30	3
CYCLE (SEC)	30	30	30	30	30
TOT NO. SESS	18	4	5	8	5
TOT NO. RESP	129	169	120	53	75
NO. RESP LAST 3 DAYS	25	135	59	36	37
NO. RESP LAST 3 DAYS/OPP	.016	.912	.050	.010	.097
% TRIALS WITH RESP (LAST 3 DAYS)	.167	.900	.393	.240	.247

TABLE 2 (continued)

	B-2				
TRIAL/CYCLE	.40	.10	.40	1.0	.10
TRIAL (SEC)	12	3	12	30	3
CYCLE (SEC)	30	30	30	30	30
TOT NO. SESS	12	4	7	8	3
TOT NO. RESP	54	151	213	76	112
NO. RESP LAST 3 DAYS	16	123	94	4	112
NO. RESP LAST 3 DAYS/OPP	.009	.537	.094	.0009	.416
% TRIALS WITH RESP (LAST 3 DAYS)	.107	.820	.627	.027	.747

TABLE 2 (continued)

	A-3					
TRIAL/CYCLE	.20	1.0	.10	.20	.80	.20
TRIAL (SEC)	6	30	3	6	24	6
CYCLE (SEC)	30	30	30	30	30	30
TOT NO. SESS	15	7	3	7	7	7
TOT NO. RESP	113	10	0	59	18	51
NO. RESP LAST 3 DAYS	19	0	0	25	1	39
NO. RESP LAST 3 DAYS/OPP	.023	.000	.000	.031	.0003	.054
% TRIALS WITH RESP (LAST 3 DAYS)	.127	.000	.000	.167	.0003	.260

TABLE 2 (continued

	C-3						
TRIAL/CYCLE	.80	.10	1.0	.20	.10	.20	.80
TRIAL (SEC)	24	3	30	6	3	6	24
CYCLE (SEC)	30	30	30	30	30	30	30
TOT NO. SESS	12	9	5	6	6	6	6
TOT NO. RESP	1	63	12	43	15	76	44
NO. RESP LAST 3 DAYS	0	30	0	21	14	40	3
NO. RESP LAST 3 DAYS/OPP	.000	.077	.000	.025	.032	.050	.0008
% TRIALS WITH RESP (LAST 3 DAYS)	.000	.200	.000	.140	.093	.267	.020

TABLE 2 (continued)

B-4

TRIAL/CYCLE	.40	.10	1.0	.20	.40
TRIAL (SEC)	12	3	30	6	12
CYCLE (SEC)	30	30	30	30	30
TOT NO. SESS	12	8	9	4	11
TOT NO. RESP	68	63	160	61	228
NO. RESP LAST 3 DAYS	10	30	69	50	61
NO. RESP LAST 3 DAYS/OPP	.006	.077	.022	.071	.049
% TRIALS WITH RESP (LAST 3 DAYS)	.067	.200	.460	.333	.407

TABLE 2 (continued)

	D-1				
TRIAL/CYCLE	1.0	.20	.10	.80	1.0
TRIAL (SEC)	30	6	3	24	30
CYCLE (SEC)	30	30	30	30	30
TOT NO. SESS	18	8	6	5	4
TOT NO. RESP	32	62	54	204	136
NO. RESP LAST 3 DAYS	10	31	27	112	93
NO. RESP LAST 3 DAYS/OPP	.002	.041	.068	.054	.035
% TRIALS WITH RESP (LAST 3 DAYS)	.067	.207	.180	.747	.620

TABLE 2 (continued)

	D-3					
TRIAL/CYCLE	1.0	.20	.10	1.0	.10	1.0
TRIAL (SEC)	30	6	3	30	3	30
CYCLE (SEC)	30	30	30	30	30	30
TOT NO. SESS	10	5	10	5	8	6
TOT NO. RESP	0	0	24	3	20	3
NO. RESP LAST 3 DAYS	0	0	12	1	11	1
NO. RESP LAST 3 DAYS/OPP	.000	.000	.0270	.0002	.0260	.0002
% TRIAL WITH RESP (LAST 3 DAYS)	.000	.000	.0800	.0070	.073	.0070

TABLE 2 (continued)

			E1		
TRIAL/CYCLE	.20	.80	1.0	.10	1.0
TRIAL (SEC)	12	48	60	6	60
CYCLE (SEC)	60	60	60	60	60
TOT NO. SESS	15	7	9	5	5
TOT NO. RESP	127	80	22	84	31
NO. RESP LAST 3 DAYS	46	20	7	55	9
NO. RESP LAST 3 DAYS/OPP	.032	.003	.0008	.083	.001
% TRIAL WITH RESP (LAST 3 DAYS)	.307	.133	.047	.367	.060

TABLE 2 (continued)

			F-4		
TRIAL/CYCLE	.40	.10	.80	1.0	.10
TRIAL (SEC)	24	6	48	60	6
CYCLE (SEC)	60	60	60	60	60
TOT NO. SESS	15	8	5	10	5
TOT NO. RESP	76	76	40	42	142
NO. RESP LAST 3 DAYS	9	51	13	15	125
NO. RESP LAST 3 DAYS/OPP	.003	.082	.002	.0001	.415
% TRIALS WITH RESP (LAST 3 DAYS)	.060	.340	.087	.100	.833

TABLE 2 (continued)

	G-2				
TRIAL/CYCLE	.20	1.0	.10	.80	.20
TRIAL (SEC)	24	120	12	96	24
CYCLE (SEC)	120	120	120	120	120
TOT NO. SESS	19	7	10	5	3
TOT NO. RESP	206	44	63	13	26
NO. RESP LAST 3 DAYS	49	0	13	0	26
NO RESP LAST 3 DAYS/OPP	.016	.000	.007	.000	.008
% TRIALS WITH RESP (LAST 3 DAYS)	.327	.000	.87	.000	.173

Apparatus

The apparatus was the same as for preceding study except that the green jewel lamps were never lighted.

Procedure:

The six naive birds were assigned to groups by drawing band numbers; the three birds with previous history were then each assigned to groups in the same manner. The three initial conditions are indicated in Table 3. After magazine training, the six naive birds were placed on their respective conditions. The experienced birds were placed directly on their conditions. All nine birds were run daily for 50 trials.

Magazine training: This procedure was the same as for the preceding negative contingency.

Positive Fixed-Trials Autoshaping: Trials again consisted of the illumination of the response key for the specified period, after which the houselight and keylight were turned off and 4 sec of access to grain permitted. Trial values and cycle values were again specific to each group. The keylight was not terminated if a peck was made and responses could therefore be recorded for the duration of the trial. Four sec of access to grain were allowed whether or not a response had occurred during the trial stimulus period. The procedure is diagrammed in Figure 1 (D).

TABLE 3

Initial Treatment Conditions Under Fixed-Trial Positive Automaintenance

SUBJECT	TRIAL	CYCLE	TRIAL/CYCLE
P2, P5, P8	12 sec	60 sec	.20
C3, P1, P6	12 sec	30 sec	.40
P3, P4, P7	48 sec	60 sec	.80

The fixed-trial procedure allows the computation of two additional measures: a response rate computed over the total sec of trial time (overall trial rate), and a response rate computed on the basis of trial time excluding time prior to the first trial response and excluding the first response (working rate). Also recorded on counters were the number of pre-trial responses, number of trial responses, number of trials, number of reinforcements, first trial of the session containing a response, and number of trials with a response. A running-time meter recorded the total number of sec prior to a trial response, which included the total time of trials without a response.

Individual manipulations: When it was clear that some birds on the initial conditions were steadily responding at a high rate, these birds were moved to a condition which, from information received from the previous negative contingency study, should occasion lower response rates and responding on a lower percentage of the trials. Likewise, those birds which had failed to respond on their initial conditions were moved to a condition which usually occasioned a higher rate of responding. These birds were then taken through several reversals in an attempt to further manipulate responding. The sequence for each subject is indicated in Table 4.

TABLE 4

Individual Manipulations on Positive Automaintenance: Five Dependent Measures Summarized Over Last Three Days on Each Condition

P-5

CONDITION	1	2	3	4
CYCLE	60	60	200	80
TRIAL	12	48	24	6
TRIAL/CYCLE	.20	.80	.20	.20
NO. RESPONSES	2570	92	201	1177
% TRIALS W RESP	100.0	9.3	53.3	98.0
MAXIMUM RESP ANY ONE SESS	925	79	86	465
$\bar{X}$ WORKING RATE	1.7661	.0951	.0447	1.5013
$\bar{X}$ OVERALL TRIAL RATE	1.4278	.0128	.0335	1.3078

CONDITION	5	6	7	8
CYCLE	30	120	120	60
TRIAL	24	24	24	24
TRIAL/CYCLE	.80	.20	.20	.40
NO. RESPONSES	5	70	98	45
% TRIALS W RESP	2.7	13.3	29.3	19.3
MAXIMUM RESP ANY ONE SESS	5	49	58	19
$\bar{X}$ WORKING RATE	.00	.1197	.0726	.0475
$\bar{X}$ OVERALL TRIAL RATE	.0014	.0194	.0272	.0125

TABLE 4 (continued)

P-8

CONDITION	1	2	3	4
CYCLE	60	60	300	30
TRIAL	12	48	60	6
TRIAL/CYCLE	.20	.80	.20	.20
NO. RESPONSES	275	272	70	403
% TRIALS W RESP	70.7	19.3	22.7	84.0
MAXIMUM RESP ANY ONE SESS	163	118	31	204
$\bar{X}$ WORKING RATE	.1501	.0919	.0156	.5431
$\bar{X}$ OVERALL TRIAL RATE	.1517	.0378	.0078	.4478

CONDITION	5	6	7
CYCLE	30	120	60
TRIAL	24	24	24
TRIAL/CYCLE	.80	.20	.40
NO. RESPONSES	93	85	47
% TRIALS W RESP	22.0	20.7	15.4
MAXIMUM RESP ANY ONE SESS	71	47	22
$\bar{X}$ WORKING RATE	.1007	.0917	.0413
$\bar{X}$ OVERALL TRIAL RATE	.0258	.0236	.0130

TABLE 4 (continued)

C-3

CONDITION	1	2	3	4
CYCLE	30	60	200	30
TRIAL	12	48	40	6
TRIAL/CYCLE	.40	.80	.20	.20
NO. RESPONSES	35	18	132	180
% TRIALS W RESP	16.0	8.0	42.7	59.3
MAXIMUM RESP ANY ONE SESS	13	8	64	93
$\bar{X}$ WORKING RATE	.0314	.00	.0363	.3654
$\bar{X}$ OVERALL TRIAL RATE	.0194	.0025	.0220	.2000

CONDITION	5	6	7
CYCLE	30	120	60
TRIAL	24	24	24
TRIAL/CYCLE	.80	.20	.40
NO. RESPONSES	40	53	258
% TRIALS W RESP	18.7	21.3	74.0
MAXIMUM RESP ANY ONE SESS	22	41	120
$\bar{X}$ WORKING RATE	.0212	.0183	.0799
$\bar{X}$ OVERALL TRIAL RATE	.0111	.0147	.0717

TABLE 4 (continued)

P-6

CONDITION	1	2	3	4
CYCLE	30	60	120	120
TRIAL	12	12	24	24
TRIAL/CYCLE	.40	.20	.20	.20
NO. RESPONSES	595	139	8	664
% TRIALS W RESP	93.3	61.3	3.3	90.7
MAXIMUM RESP ANY ONE SESS	225	55	6	357
$\bar{X}$ WORKING RATE	.3901	.0520	.0 0	.1670
$\bar{X}$ OVERALL TRIAL RATE	.3305	.0772	.0022	.1844

P-2

CONDITION	1	2	3
CYCLE	60	120	60
TRIAL	12	12	6
TRIAL/CYCLE	.20	.10	.10
NO. RESPONSES	85	198	206
% TRIALS W RESP	40.0	74.0	76.7
MAXIMUM RESP ANY ONE SESS	31	78	77
$\bar{X}$ WORKING RATE	.0721	.0983	.2289
$\bar{X}$ OVERALL TRIAL RATE	.0472	.1100	.1865

RESULTS

Experiment I

Because autoshaping and automaintenance have only recently become topics of investigation, there is no standard manner of data presentation with which to argue the effectiveness of any given manipulation. Some measures which have been used include number of pairings prior to the first response and percentage of subjects to "autoshape" (Brown and Jenkins, 1968), cumulative responses and percentage of trials on which a response occurred (Williams and Williams, 1969), and rate of responding (Gamzu and Williams, 1971; Schwartz, 1972). Some of these measures are appropriate in the present context, and they will be presented along with some other indicators. "Rate" as a dependent measure is appropriate only in a fixed-trials condition.

The results obtained here were examined in light of two main independent variables. Groups of subjects differed with respect to (1) absolute duration of the trial stimulus, and (2) absolute duration of the total cycle. In addition to these basic measures, data were also considered with respect to the proportion of the total cycle occupied by the trial stimulus. Although these three aspects clearly do not vary independently of one another, they serve as convenient ways in which to categorize the data obtained. Most measures are presented in the form of means computed across all subjects of which the group in question is comprised. For two measures (number of pairings and number of cumulated sec of trial time prior to the first response), means cannot include data for those birds on the condition which did _not_ respond. The more appropriate computation for such a measure is the median, which is presented along with the mean data for birds which _did_ respond. Data in all cases are presented with respect to the first ten days of exposure to the initial negative-contingency condition. Data from individual manipulations are usually presented from the last three days of exposure to any given condition.

Absolute trial-stimulus duration: The absolute duration of the trial stimulus could influence responding in several ways. In one sense, the longer the stimulus availability, the greater the opportunity for a keypeck to be observed, suggesting, perhaps, that most responding would be observed on the longer stimulus conditions. On the other hand, the shorter the trial-stimulus duration, the greater the contiguity of its onset and the delivery of grain. The more immediate the grain presentation, the greater the "excitement" or "expectancy" of food.

Several measures, summarized in Table 5, reflect the effectiveness of the various stimulus-duration groups. Irrespective of which condition is most effective in maintaining responding, it is of interest to see under which condition the pecking response appears earliest. Acquisition should vary in the different groups if the stimuli are differentially effective in "educing" the keypeck. Number of pairings prior to the first response (a measure similar to that reported by Brown and Jenkins [1968]) is plotted for the various groups in Figure 2. The fewer the pairings required before the occurrence of the first response, the more "potent" the condition might be considered, with respect to its effectiveness in educing the first response in the pigeon. Each bar for the mean data in this figure represents the data for birds which did produce at least one keypeck over the first ten days of the condition. Medians are computed for all birds on the condition, and therefore are probably the more appropriate measure for this dependent variable. In actuality, although some specific groups show a larger value for the median than they show for the mean, the general relationships among the groups are the same for both measures.

From Figure 2 it can be seen that, although the 6- and 12-sec groups required fewer pairings than did the

TABLE 5

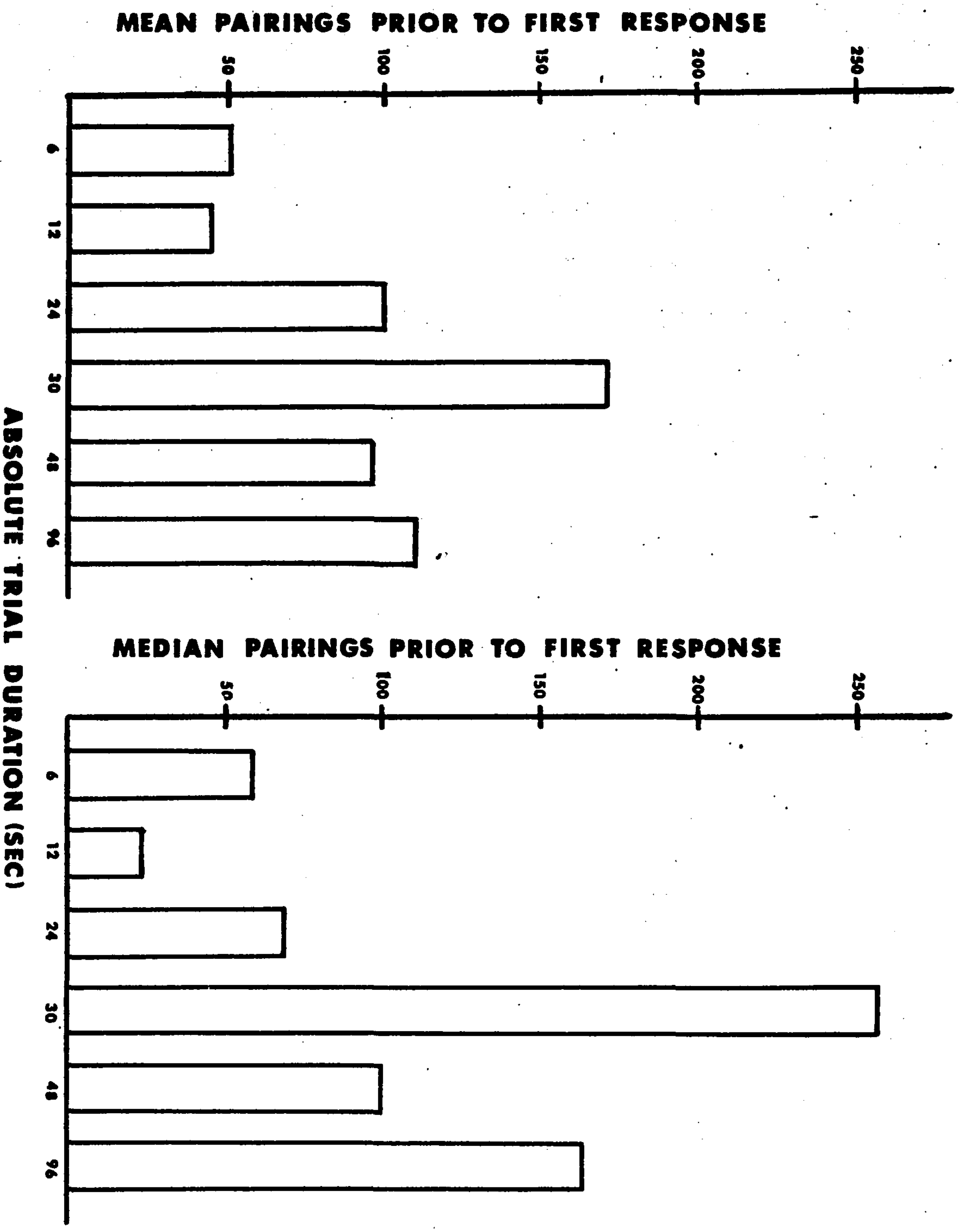
Negative-Contingency Autoshaping: Summary by Absolute Trial Duration Over First Ten Days of Condition

trial duration(sec)	6	12	24	30	48	96
N	4	8	12	4	4	4
mean no pairings prior to first resp	52.5	45.0	100.2	171.3	97.5	112.0
median no pairings prior to first resp	59.5	23.0	68.0	256.5	99.5	163.0
mean sec of trial time accumulated prior to first resp	315	540	2404	5140	4680	10752
median sec of trial time accumulated prior to first resp	357	276	1632	7425	4776	15648
% Ss which never made a resp	00	00	16.7	25.0	00	25.0
% Ss never resp on ≧ 10% daily trials	00	25	41.7	75.0	50.0	50.0
mean resp	64.75	60.13	32.33	2.0	9.0	8.75

TABLE 5 (continued)

trial duration(sec)	6	12	24	30	48	96
N	4	8	12	4	4	4
$\frac{\text{MEAN RESP}}{\text{theoretical opportunity}}$	10.79	5.01	1.35	.065	.19	.04
$\frac{\text{mean resp}}{\text{actual opportunity}}$	.0240	.0136	.0030	.0002	.0004	.0002
mean maximum resp for any one session	15.00	17.25	10.00	2.25	6.25	3.50
$\frac{\text{mean maximum resp}}{\text{theoretical opportunity}}$	2.50	1.43	.305	.073	.130	.030

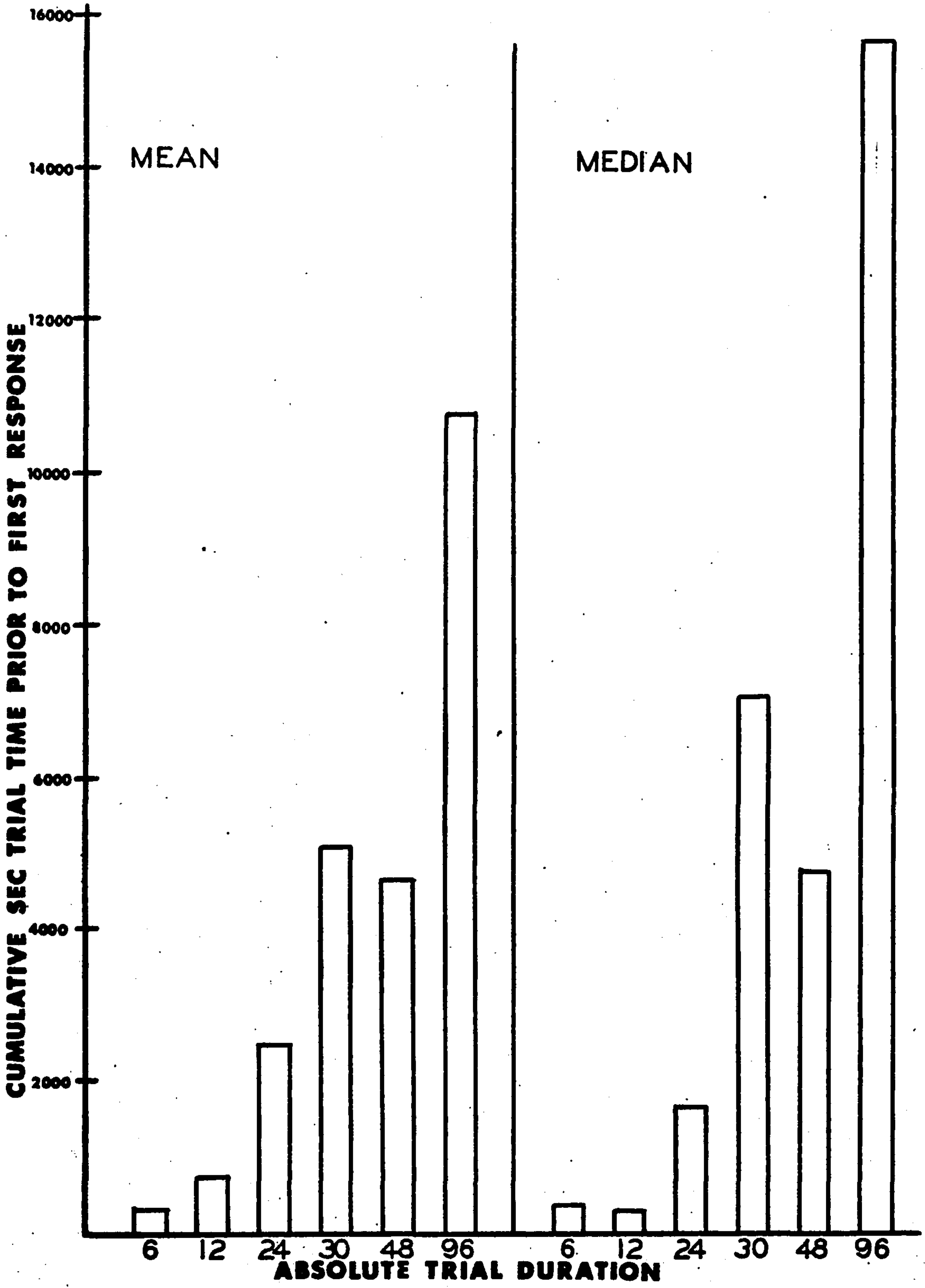
Figure 2. Mean and median pairings of the keylight with the presentation of grain prior to the first recorded keypeck, plotted as a function of specific absolute trial durations.


MEAN PAIRINGS PRIOR TO FIRST RESPONSE
50
100
150
200
250
6
12
24
30
48
96
MEDIAN PAIRINGS PRIOR TO FIRST RESPONSE
50
100
150
200
250
6
12
24
30
48
96
ABSOLUTE TRIAL DURATION (SEC)

longer stimulus-duration groups, there are no overall trends apparent. The 30-sec group was exposed to more pairings before the appearance of the first response than were either the 48- or 96-sec groups. There is one sense, however, in which the mere number of pairings prior to the first response is not a fair measure of acquisition. For the longer stimulus groups, the total exposure time of the trial stimulus is greatly increased over that for the shorter stimulus groups. In other words, there is a great deal more time available in which a response can occur. One way to allow for this increased availability is to "weight" the number of actual pairings by the availability on each of these pairings, resulting in a measure which can be seen to equal the total sec of trial time cumulated prior to the first response.

Presented in Figure 3, these data appear somewhat more orderly than do those for the simple number of pairings seen in the preceding figure. For both means and medians (medians are again more representative here, but the relationships depicted are similar for the two measures), it can be seen that the greatest amount of trial time is cumulated before the occurrence of a response in the longer stimulus conditions. The 30- and 48-sec groups appear to be reversed, but generally, as the value of the trial stimulus increases, an increasingly greater number of sec are cumulated

Figure 3. Mean and median sec of trial time (keylight on) cumulated prior to the first recorded keypeck, plotted as a function of specific absolute trial durations.


16000
14000
12000
10000
8000
6000
4000
2000
CUMULATIVE SEC TRIAL TIME PRIOR TO FIRST RESPONSE
MEAN
MEDIAN
6
12
24
30
48
96
6
12
24
30
48
96
ABSOLUTE TRIAL DURATION

prior to the first response. Looking at the median data, one can see that almost 16,000 sec of trial time passed before responding was initiated in the 96-sec group, while less than 400 sec passed before the 6-sec birds first began to peck.

As mentioned above, all birds did not eventually make a response over the first ten days of the condition. This failure to respond is perhaps one of the strongest consequences of a condition which is not optimal for the production of keypecking. As can be seen in Table 5, all birds in the 6-sec and 12-sec groups made at least one keypeck during the first ten days of the condition, whereas 2 out of 12 (16.7%) never responded in the 24-sec group, and 1 out of 4 (25%) never responded in both the 30-sec and 96-sec groups. All birds in the 48-sec group made at least one keypeck. Taking an even more rigorous criterion, responding on at least 10% of the daily trials (Williams and Williams, 1969), all 6-sec birds reached the criterion in the first ten days, while 25% of the 12-sec, 42% of the 24-sec, 75% of the 30-sec, and 50% of each of the 48-sec and 96-sec groups did not reach the criterion in that time period. In terms, then, of whether or not responding occurred at all, and, if so, did it ever occur at the level of or greater than 10% of the daily trials, the shorter stimulus conditions seemed generally to be more effective than the long stimulus conditions. Additionally, if responding did occur, the data from Figures 2 and 3 demonstrate that such responding occurred after both fewer pairings and fewer sec of cumulated trial time for the shorter stimulus-duration groups.

Figure 4 shows responses totaled over the first ten days of each of the negative-contingency conditions for each stimulus duration. Each bar represents the mean figure for the total number of subjects run with the indicated duration. As a function of increasing trial duration, a decreasing number of responses can generally be seen, with the only exception being the 30-sec group. The longer the trial stimulus, the greater is the opportunity for a response to be made during its presentation, but this figure shows very clearly that the longer stimuli are the occasion for much less responding than are the shorter stimuli. In fact, the means for the 6- and 12-sec groups are approximately six times those for the 48- and 96-sec groups.

A similar picture can be seen in Figure 5, which presents the mean data for yet another dependent measure: maximum number of responses recorded for any one session across the first ten days of the initial condition. Again, these maximums are plotted as a function of trial size. The 6- and 12-sec groups appear to be reversed from the preceding figure, but generally, the same conclusion can be supported as that drawn from Figure 4: fewer responses are

Figure 4. Mean no. of responses recorded over the first ten days of the initial negative-contingency condition, plotted as a function of specific absolute trial durations.

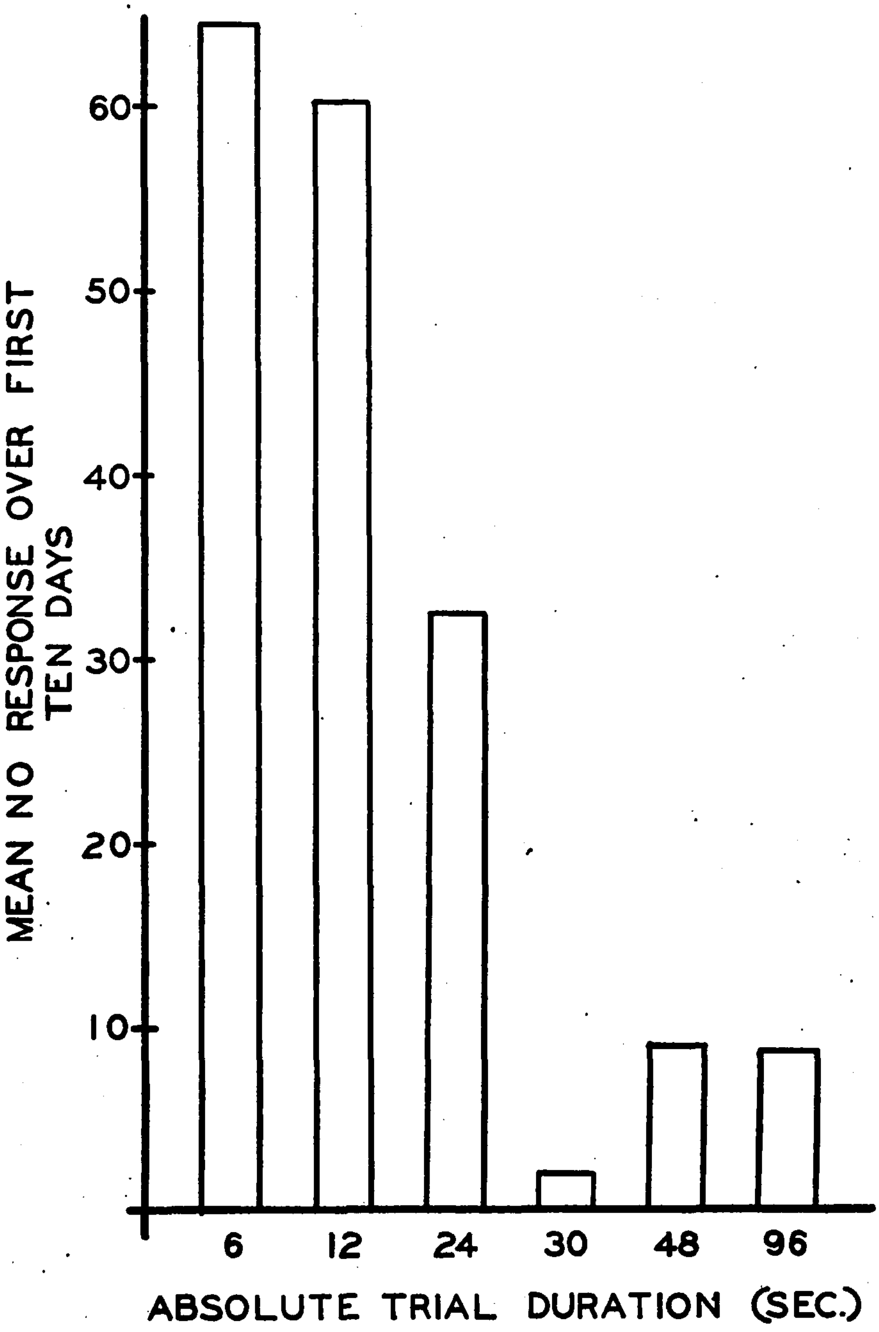
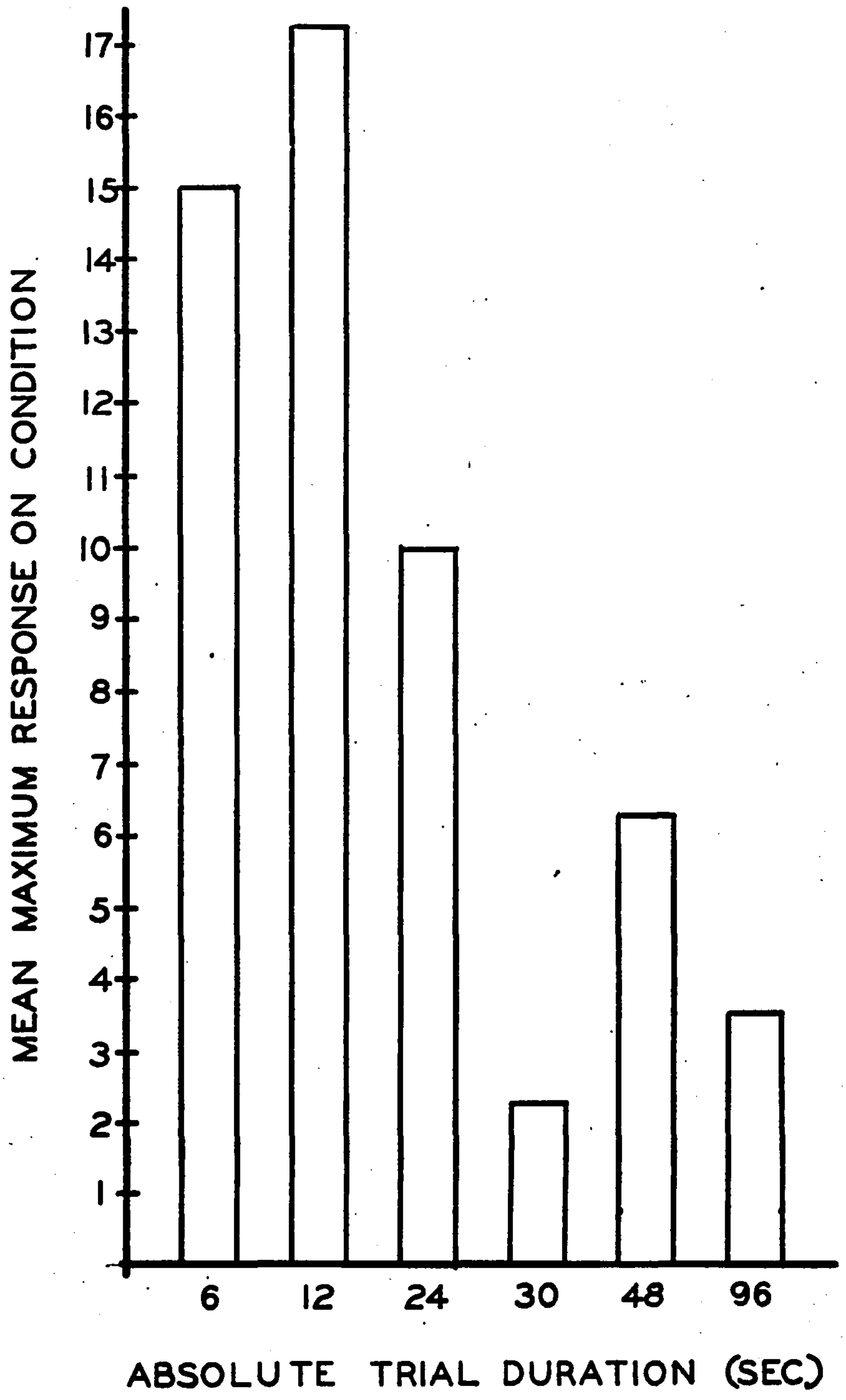

MEAN NO RESPONSE OVER FIRST TEN DAYS
60
50
40
30
20
10
6
12
24
30
48
96
ABSOLUTE TRIAL DURATION (SEC.)

Figure 5. Mean maximum responses recorded for any one session over the first 10 days of the initial negative-contingency condition, plotted as a function of specific absolute trial durations.


MEAN MAXIMUM RESPONSE ON CONDITION
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
6
12
24
30
48
96
ABSOLUTE TRIAL DURATION (SEC)

likely to be made on the longer stimulus conditions than on the shorter stimulus conditions.

As mentioned above, the data in these two figures are obviously biased by "opportunity to respond." The trial stimulus is available on each trial for much greater periods of time in the long stimulus conditions than in the shorter stimulus conditions. Given that the general procedure functions to "educe" some tendency to respond on the lighted key, the birds in the longer stimulus conditions have much more time for the peck to "build up" and actually occur. Some sort of weighting, then, might be made to take into account the time available for a response to occur. One way to do so is to consider the total of trial stimulus availability given that no responding occurred, in other words, simply to weight by the differential trial times. These revised mean data are presented in Figure 6 for the number of responses totaled over the first ten days, and in Figure 7 for the maximum number of responses occurring on any given session over the first ten days of the condition. Although there are some specific reversals (the 48-sec group is slightly out of line in Figure 6 and in Figure 7), when both of these measures are corrected for theoretical opportunity to respond, the shorter trial times are still generally more effective than the longer ones.

There are problems involved with this measure of "opportunity," although it is fairer than no correction at

Figure 6. Mean no. of responses recorded over the first ten days of the initial negative-contingency condition, corrected by the theoretical opportunity per trial (see text), and plotted as a function of specific absolute trial durations.

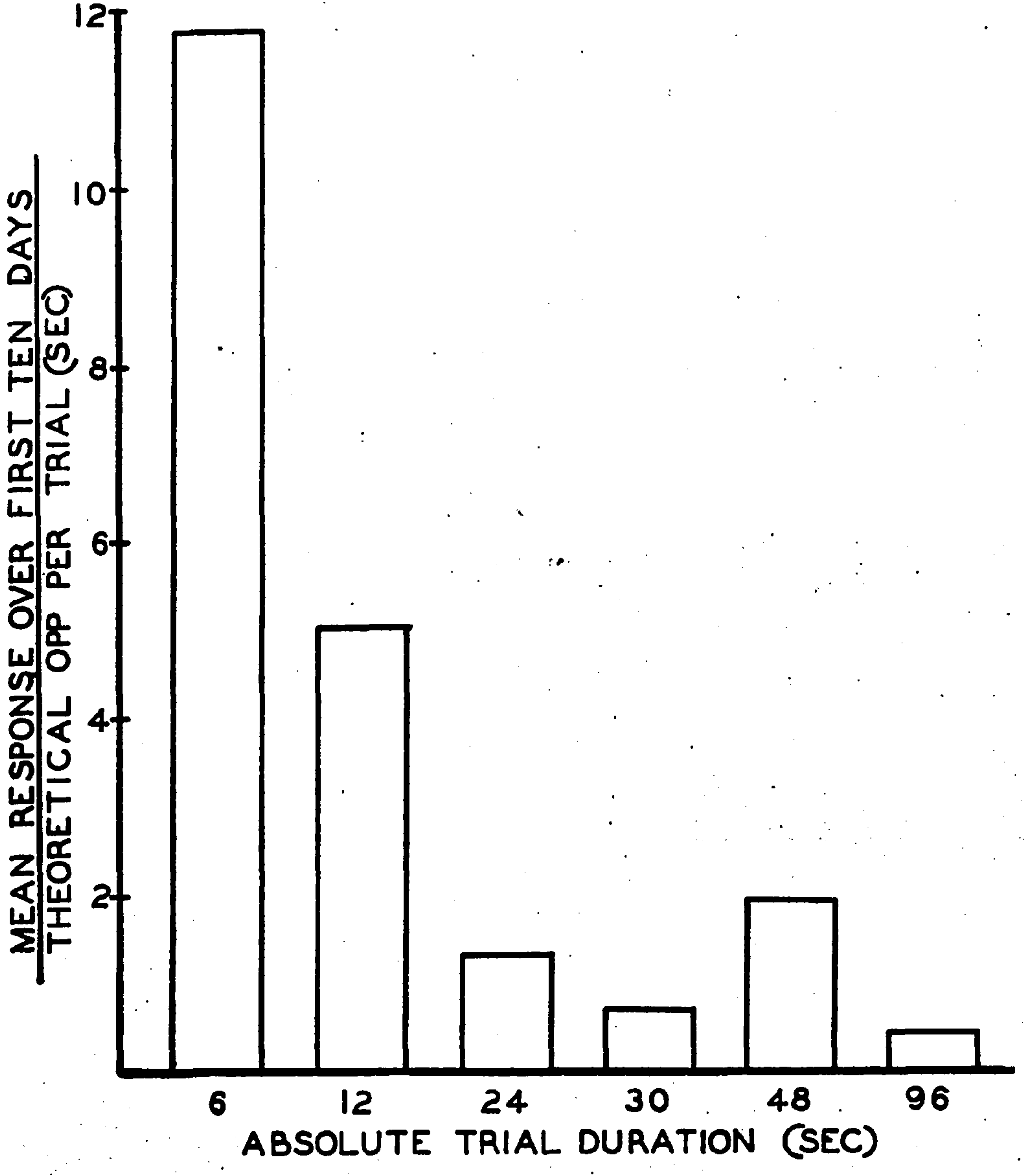
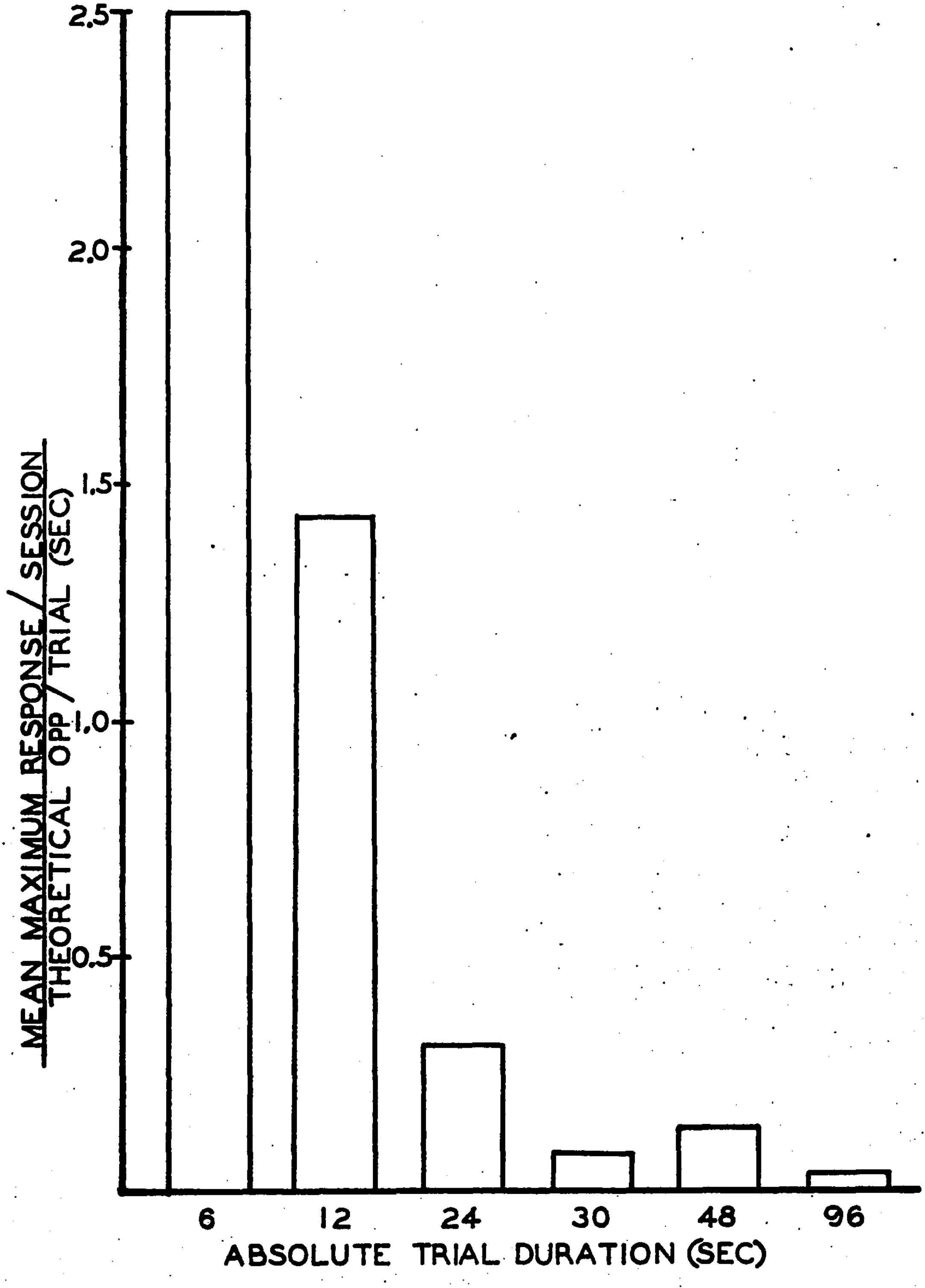

MEAN RESPONSE OVER FIRST TEN DAYS
THEORETICAL OPP PER TRIAL (SEC)
12
10
8
6
4
2
6
12
24
30
48
96
ABSOLUTE TRIAL DURATION (SEC)

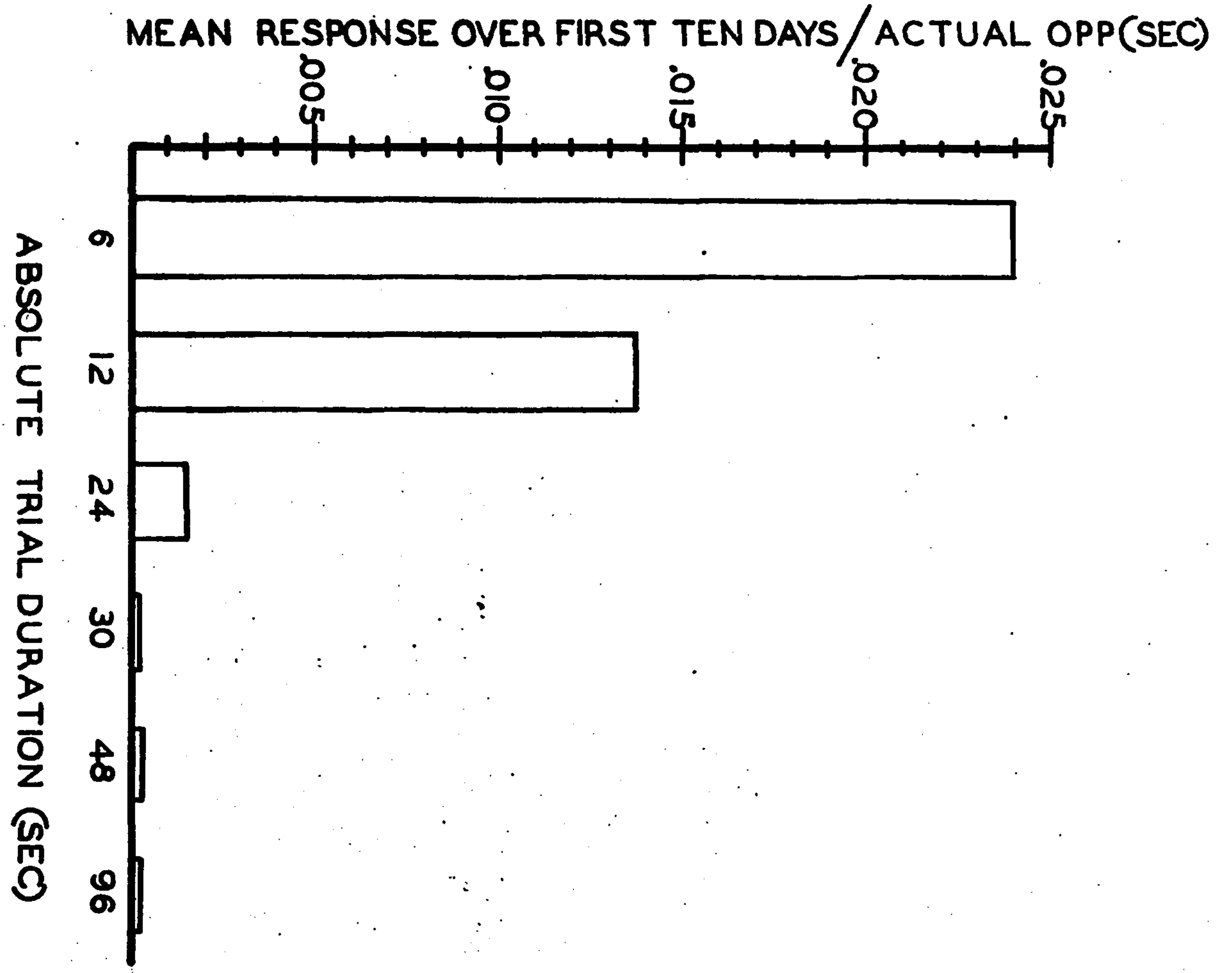
Figure 7. Mean maximum no. of responses recorded for any one session over the first ten days of the initial negative-contingency condition, corrected for the theoretical opportunity per trial (see text), and plotted as a function of specific absolute trial durations.


2.5
2.0
1.5
1.0
0.5
MEAN MAXIMUM RESPONSE / SESSION
THEORETICAL OPP / TRIAL (SEC)
6
12
24
30
48
96
ABSOLUTE TRIAL DURATION (SEC)

all. Among these difficulties is the fact that it represents the "actual" opportunity to respond only when *no* responding occurs to cancel the trial light. Instead, opportunity might be more appropriately considered only the "light-on" time. In other words, all of the trial time which was canceled after the occurrence of a trial response should *not* be included in the opportunity measure. Figure 8 shows the original data, number of trial responses totaled over the first ten days, divided by the total number of sec in which the key was actually lighted (over the first ten days). As can be seen by a comparison with Figure 6, the relationships expressed in this figure and in that in which the correction was made in terms of "theoretical" opportunity are actually very similar, the only difference being that the correction in real time pushes responding on the longer trial durations even further below responding on the shorter trials than does a correction in theoretical availability.

It might be concluded, then, on the basis of cumulated pairings and sec prior to the first response, percentage of subjects to exhibit the pecking response and to produce it on at least 10% of the daily trials, and number of responses and maximum number of responses per session, that the pecking response was most effectively produced and maintained under the shorter stimulus conditions.

Figure 8. Mean no. of responses recorded over the first ten days of the initial negative-contingency condition, corrected by the actual sec for which the keylight was lighted, and plotted as a function of specific absolute trial durations.


MEAN RESPONSE OVER FIRST TEN DAYS/ACTUAL OPP(SEC)
.005
.010
.015
.020
.025
6
12
24
30
48
96
ABSOLUTE TRIAL DURATION (SEC)

Cycle size: It is possible that the absolute duration of the cycle itself would exert a strong enough effect to show systematic relationships with dependent variables such as those examined in the preceding section. Absolute cycle size determines how often a bird will receive grain in the experimental chamber. It might be expected, therefore, that the 30-sec cycle would always occasion more responding and more rapid acquisition than the 60-sec cycle or the 120-sec cycle, regardless of the actual length of the trial stimulus itself. Table 6 summarizes the data for groups broken down into absolute cycle durations for a number of dependent measures. Figure 9 shows the mean and median pairings prior to the first response. Means again are computed only on the basis of those birds which actually did respond, so here again the median figures are probably more appropriate. Both measures are equally inconclusive; little can be said but that the 60-sec group appears to have acquired the pecking response much more rapidly than either the 30-sec or the 120-sec group. There are no simple trends as a function of increasing cycle size. In the portion of the figure representing the mean, the 120-sec group shows slightly faster acquisition than the 30-sec group, while in the median figure, the 30-sec group shows slightly faster acquisition than the 120-sec group.

When the number of pairings is weighted by the trial duration, as in Figure 10, the cumulative sec prior to the

TABLE 6

Negative-Contingency Autoshaping: Summary by Absolute Cycle Duration Over First Ten Days of Condition

cycle duration (sec)	30	60	120
N	16	8	12
mean no pairings prior to first resp	131.45	11.75	91.50
median no pairings prior to first resp	90.50	9.00	97.50
mean sec of trial time accumulated prior to first resp	2949.25	195.0	5664
median sec of trial time accumulated prior to first resp	1152.0	144.00	3648.00
% Ss which never made a resp	8.30	00.00	16.70
% Ss never resp on ≥ 10% daily trials	58.33	25.00	41.67
mean resp	27.62	56.37	26.17
$\frac{\text{mean resp}}{\text{theoretical opportunity}}$	3.607	3.980	.937
$\frac{\text{mean resp}}{\text{actual opportunity}}$	.0079	.0112	.0021
mean maximum resp	8.44	17.50	7.75
$\frac{\text{mean maximum resp}}{\text{theoretical opportunity}}$	.9529	1.1579	.2422

Figure 9. Mean and median pairings of keylight and grain prior to the first recorded keypeck, plotted as a function of specific absolute cycle durations.

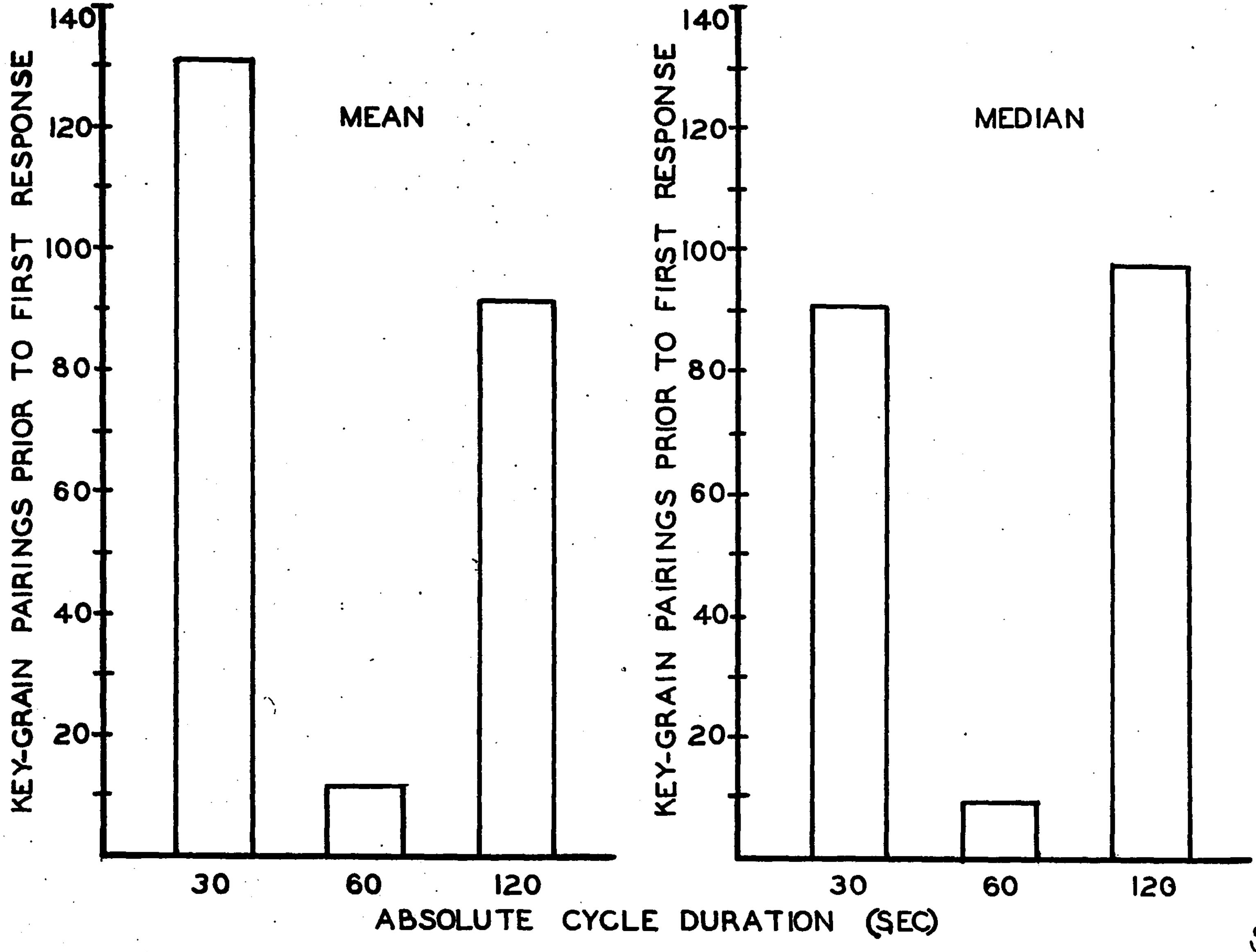
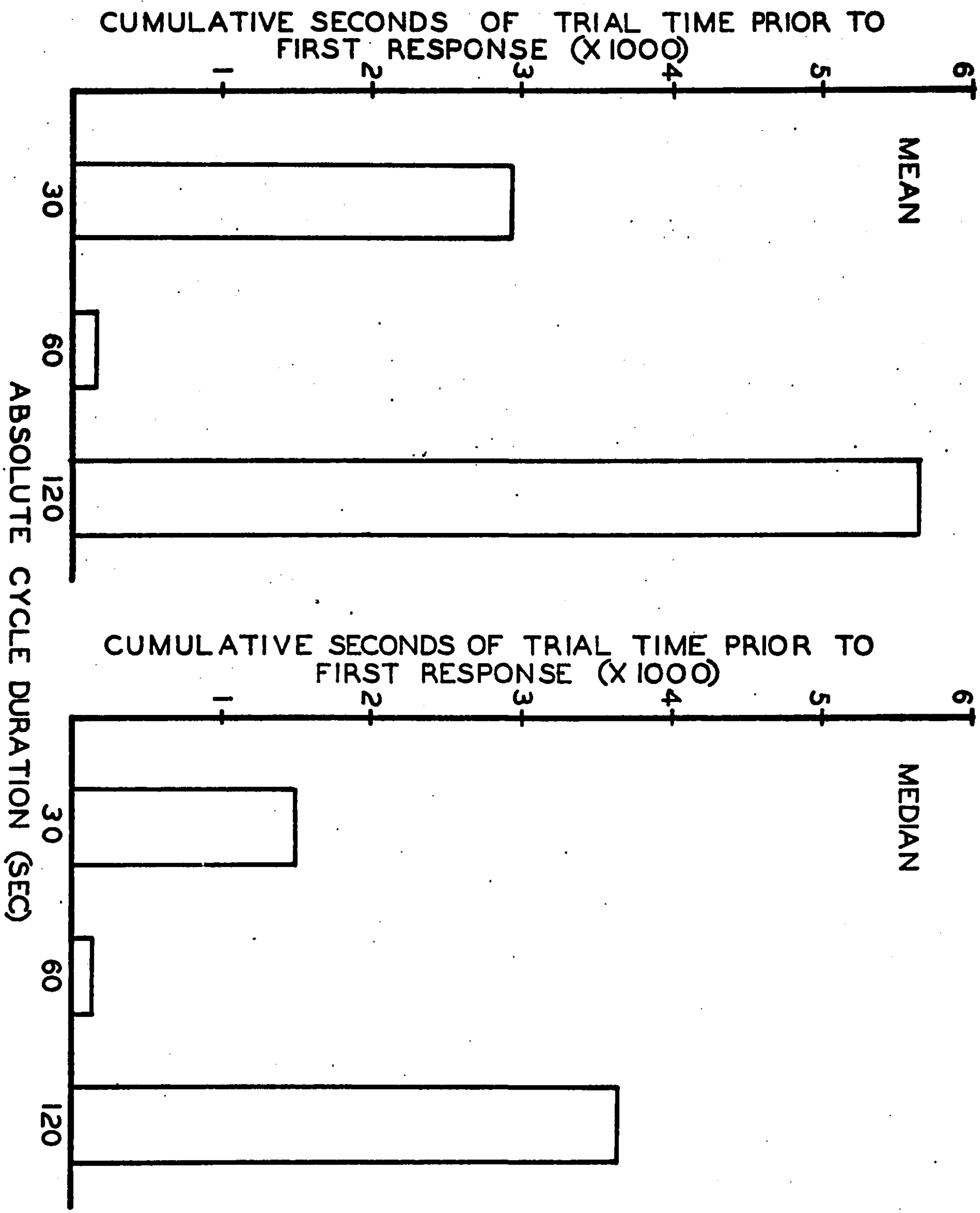

KEY-GRAIN PAIRINGS PRIOR TO FIRST RESPONSE
140
120
100
80
60
40
20
MEAN
30
60
120
KEY-GRAIN PAIRINGS PRIOR TO FIRST RESPONSE
140
120
100
80
60
40
20
MEDIAN
30
60
120
ABSOLUTE CYCLE DURATION (SEC)

Figure 10. Mean and median sec of trial time (keylight on) cumulated prior to the occurrence of the first recorded keypeck, plotted as a function of specific absolute cycle durations.


CUMULATIVE SECONDS OF TRIAL TIME PRIOR TO FIRST RESPONSE (X 1000)
1
2
3
4
5
6
MEAN
30
60
120
CUMULATIVE SECONDS OF TRIAL TIME PRIOR TO FIRST RESPONSE (X 1000)
1
2
3
4
5
6
MEDIAN
30
60
120
ABSOLUTE CYCLE DURATION (SEC)

first response still show no systematic relationships as a function of increasing cycle size. Responding was clearly most quickly produced in the 60-sec group.

From Table 6 it can be seen that the birds in the 60-sec cycle groups all made at least one keypeck over the first ten days, while 8.3% of the 30-sec cycle birds and 16.7% of the 120-sec birds failed to make at least one response during the same period. Two of the eight birds (25%) in the 60-sec group failed to reach the criterion of responding on equal to or greater than 10% of the daily trials; however, 58% of the 30-sec group and 42% of the 120-sec group never reached the criterion. On these measures too, then, the 60-sec groups showed most consistent acquisition, and maintenance more often at the level of equal to or greater than 10% of daily trials.

Figures 11 and 12 show the number of responses totaled over the first 10 days and these same data corrected for the theoretical opportunity to respond on each trial, plotted for each of the three cycle values. From these data it appears that the cycle value has no <u>overriding</u> effect on the responding generated, there being no obvious simple trends in responding as the cycle value increases. In both figures the 60-sec cycle shows more responding than either the 30-sec or 120-sec cycles. If the data are corrected for <u>actual</u> sec of trial time, as in Figure 13,

Figure 11. Mean no. of responses recorded over the first ten days of the initial negative-contingency condition, plotted as a function of specific absolute cycle durations.

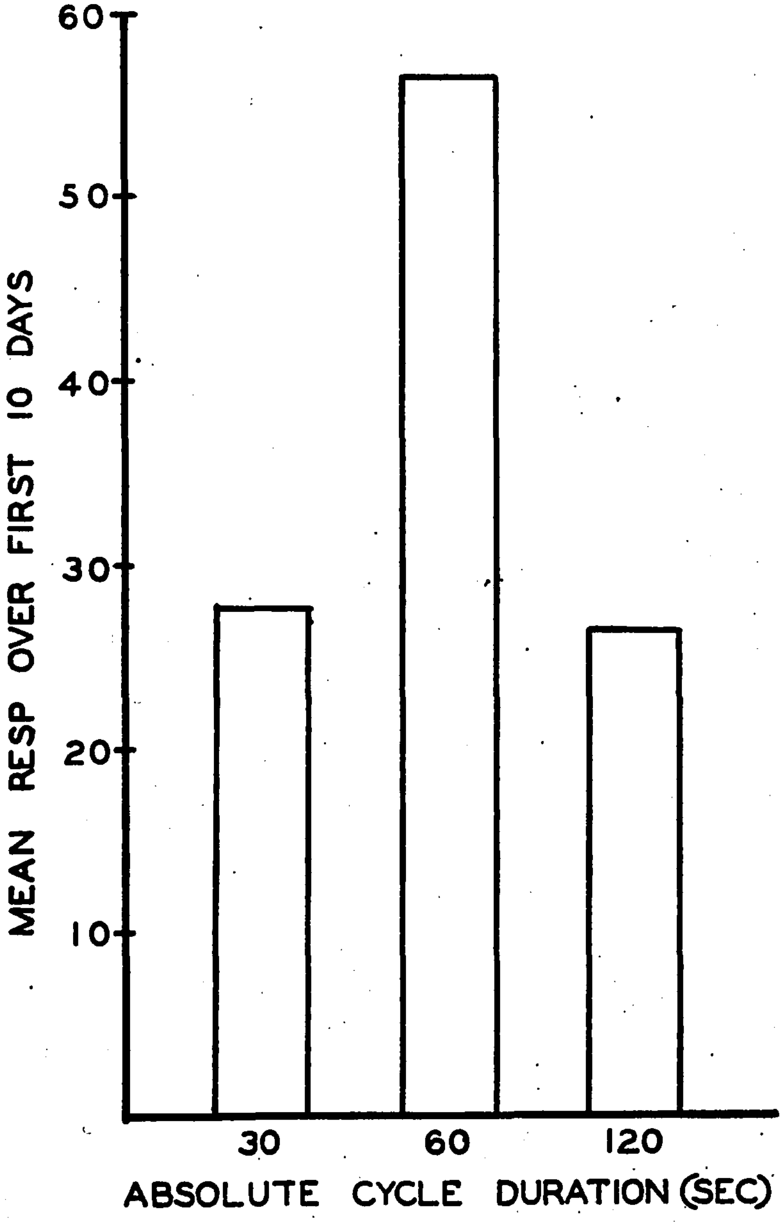

60
50
40
30
20
10
MEAN RESP OVER FIRST 10 DAYS
30
60
120
ABSOLUTE CYCLE DURATION (SEC)

Figure 12. Mean no. of responses recorded over the first ten days of the initial negative-contingency conditions, corrected for the theoretical opportunity per trial (see text), and plotted as a function of specific absolute cycle durations.

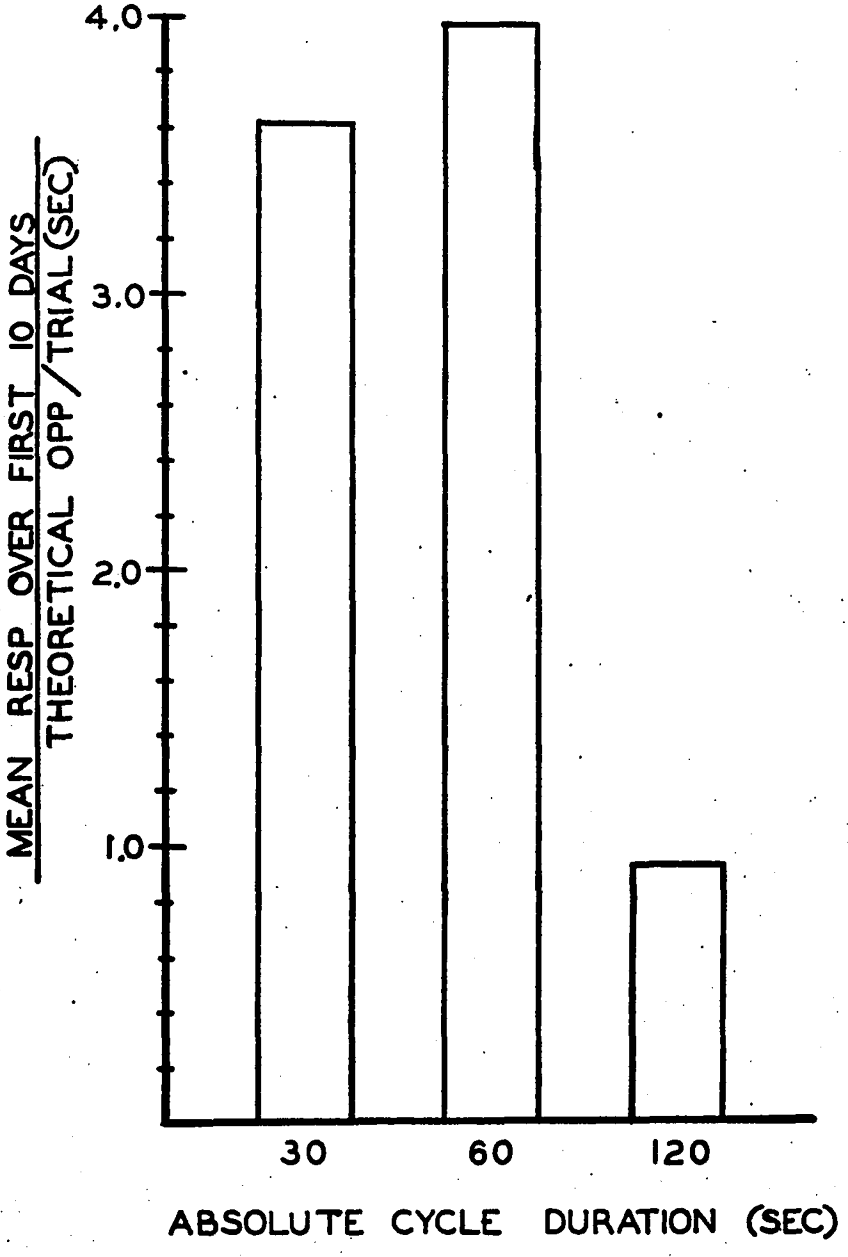
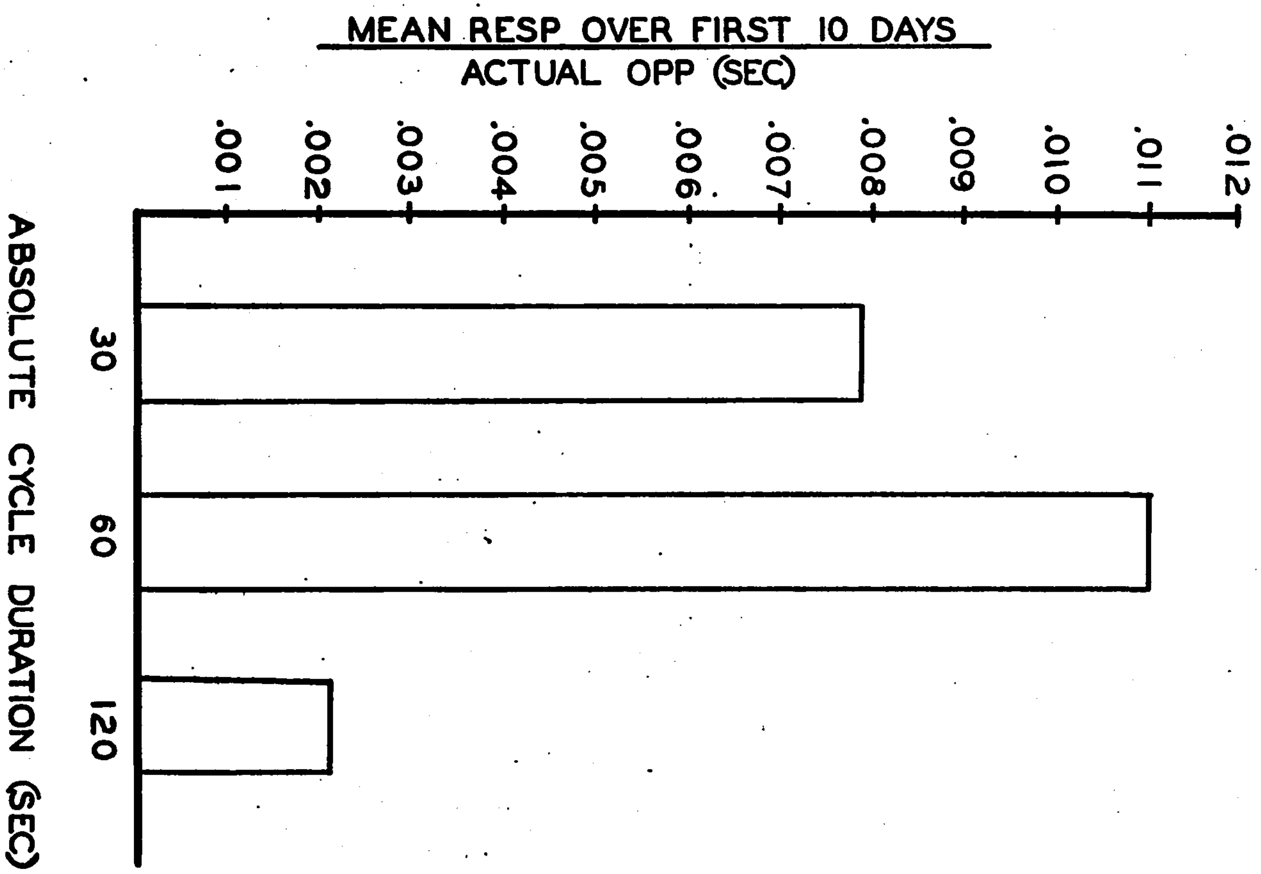

MEAN RESP OVER FIRST 10 DAYS
THEORETICAL OPP/TRIAL (SEC)
4.0
3.0
2.0
1.0
30
60
120
ABSOLUTE CYCLE DURATION (SEC)

Figure 13. Mean no. of responses recorded over the first ten days of the initial negative-contingency condition, corrected for the actual no. of sec for which the keylight was lighted, and plotted as a function of specific absolute cycle durations.


MEAN RESP OVER FIRST 10 DAYS
ACTUAL OPP (SEC)
.001
.002
.003
.004
.005
.006
.007
.008
.009
.010
.011
.012
30
60
120
ABSOLUTE CYCLE DURATION (SEC)

instead of possible (theoretical) trial time (as seen in Figure 12), the conclusions are the same: no clearcut relation between cycle size and amount of responding, with the 60-sec cycle showing the most responding.

Similar conclusions can be drawn from Figures 14 and 15, which show the maximum number of responses recorded for any one session over the first 10 days, both corrected and uncorrected for theoretical opportunity to respond. It appears then, that the absolute duration of the cycle alone has no overriding monotonic effect on either the rapidity of acquisition or on the level of maintenance of the pecking response.

Figure 16 summarizes the data for all groups for one dependent measure: mean number of responses recorded over the first ten days of each treatment condition. Each point represents the mean for the four subjects in the group. Within each cycle value (indicated by the shaded areas), the number of responses recorded is seen to change as the trial size increases. At a cycle value of 20 sec, for example, 65 responses were recorded when the trial duration was 6 sec, approximately 42 responses at a 12-sec trial, and negligible responding at 24- and 30-sec trial values. A similar decrease in responding with increases in trial value is evident across groups with 60-sec trial values.

Figure 14. Mean maximum no. of responses recorded for any one session of the initial negative-contingency condition, plotted as a function of specific absolute cycle durations.

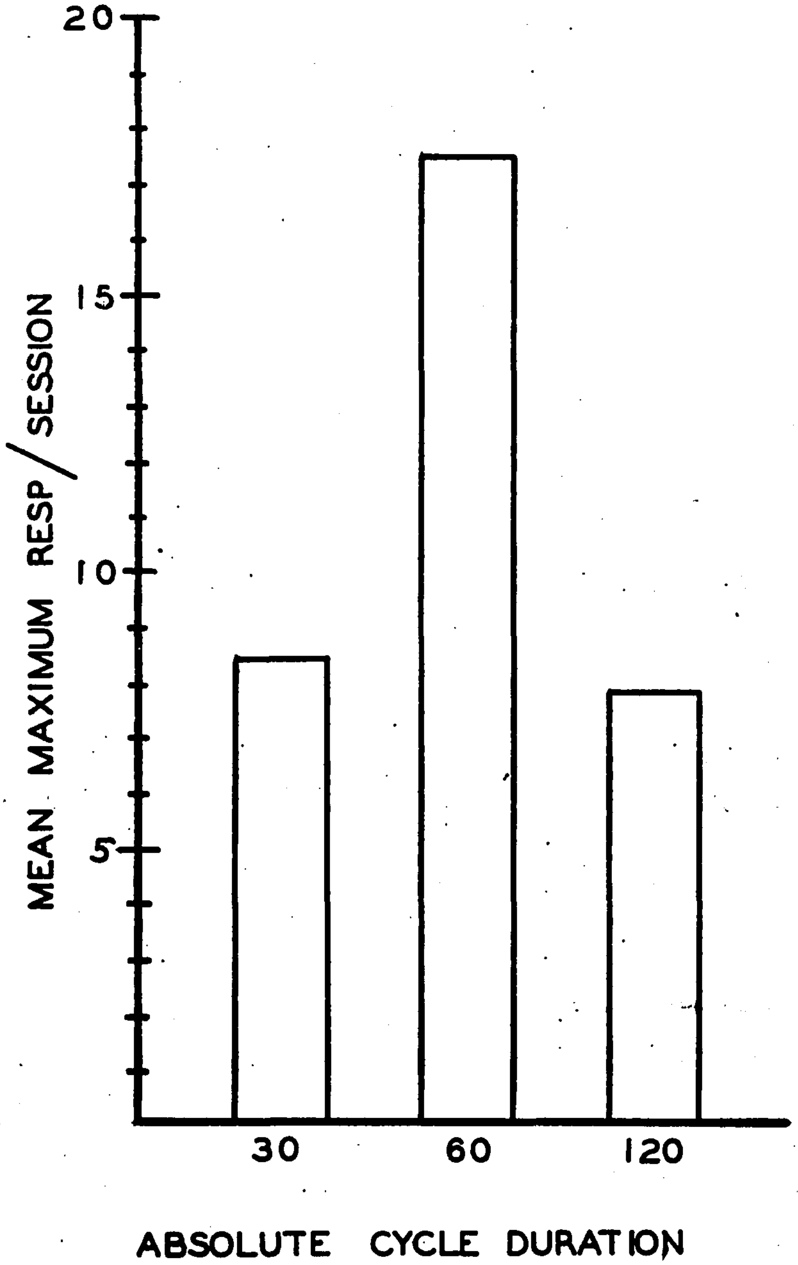

20
15
10
5
MEAN MAXIMUM RESP/SESSION
30
60
120
ABSOLUTE CYCLE DURATION

Figure 15. Mean maximum no. of responses recorded for any one session over the first ten days of the initial negative-contingency condition, corrected for theoretical opportunity to respond, and plotted as a function of specific absolute cycle durations.

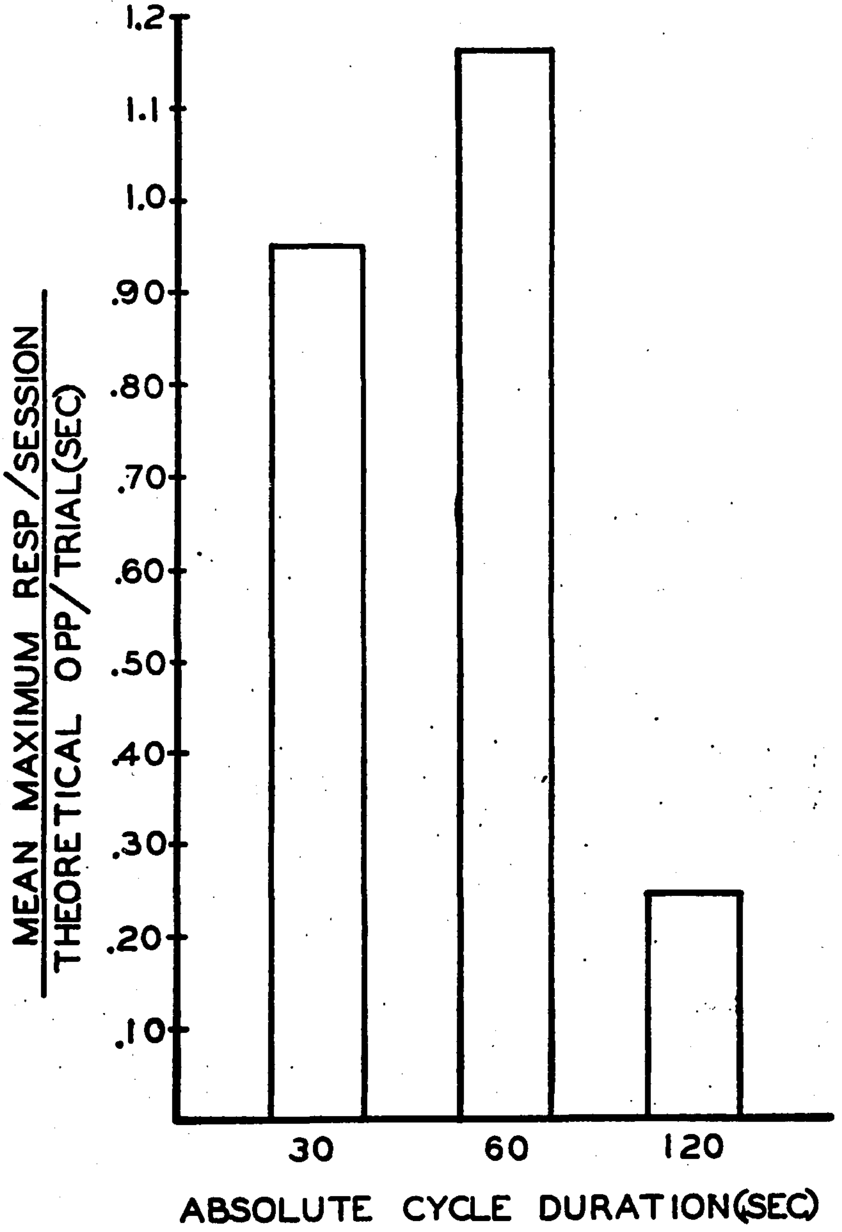
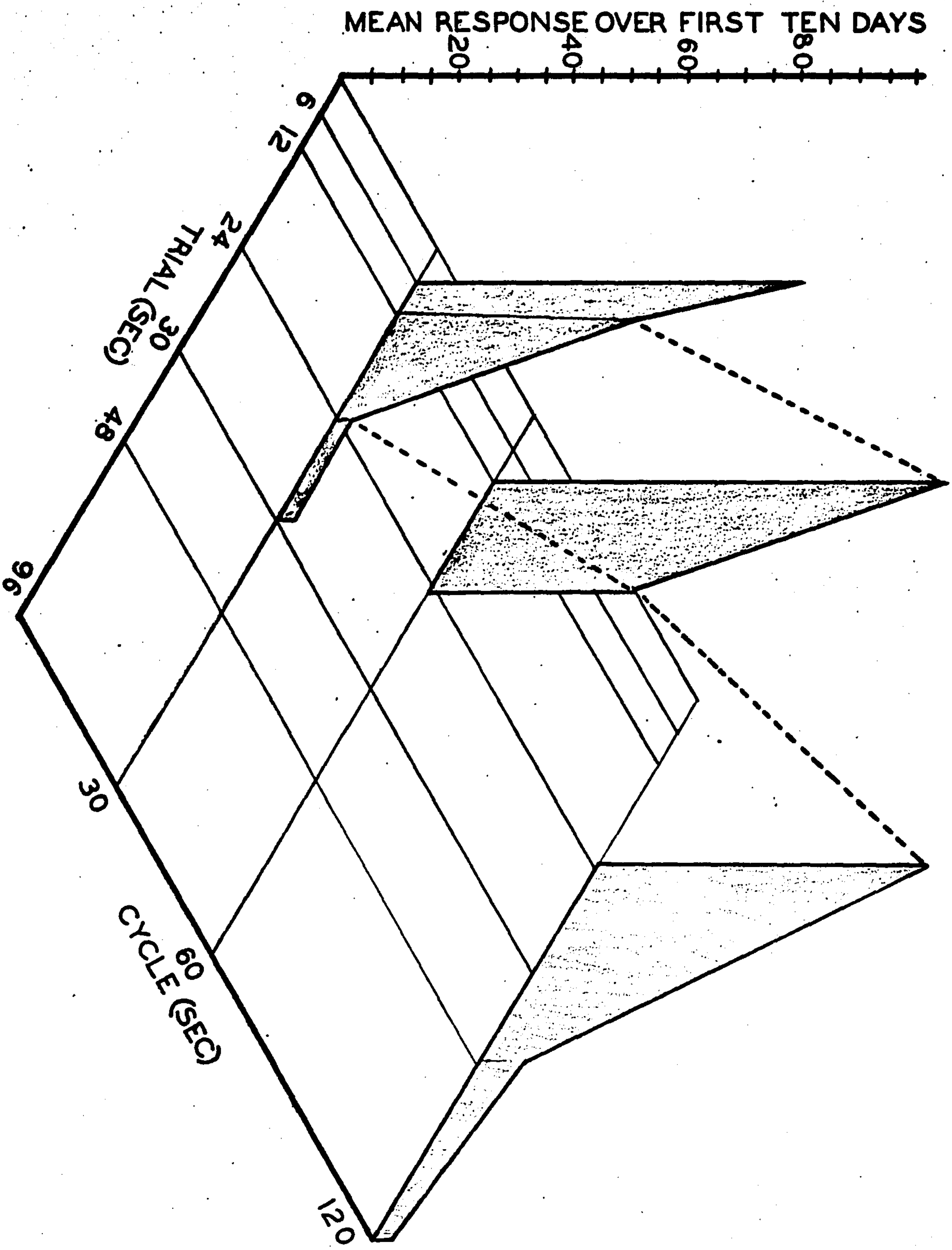

MEAN MAXIMUM RESP/SESSION
THEORETICAL OPP/TRIAL(SEC)
1.2
1.1
1.0
.90
.80
.70
.60
.50
.40
.30
.20
.10
30
60
120
ABSOLUTE CYCLE DURATION(SEC)

Figure 16. Mean no. of responses over the first ten days of the initial negative-contingency condition, plotted as a joint function of specific values of both absolute trial duration and absolute cycle duration. Shaded areas indicate increasing trial durations within each of three cycle durations. Dotted lines indicate increasing cycle durations within the two trial durations which are represented more than once.


MEAN RESPONSE OVER FIRST TEN DAYS
20
40
60
80
6
12
24
30
48
96
TRIAL (SEC)
30
60
120
CYCLE (SEC)

If any specific trial value (indicated by the dotted lines in Figure 16) is examined across several cycle values, it can be seen that responding obtained at any trial duration also predictably increases as the cycle value increases. A 24-sec trial occasions almost no responding when the cycle value is 30 sec, approximately 35 responses at a cycle of 60 sec, and 70 responses when the cycle value is 120 sec.

The best prediction of responding, then, appears to require a knowledge of both trial and cycle durations. Although an exact function relating these two parameters is, of course, not demonstrated here, a ratio formulation can predict the present data whether the constant be trial or cycle: as the ratio of trial to cycle decreases, the probability of responding increases. The ratios of .20 all occasion a fair amount of responding, the .80 and 1.0 ratios almost none at all.

The ratio of trial to cycle: To further illustrate the "ratio" effect, the data were next broken down within each overall cycle value into groups representing the various percentages of the total cycle occupied by the trial stimulus. The summaries for both individuals and groups are shown for several dependent measures in Table 7.

As presented for trial alone and cycle alone, the trial/cycle ratio can also be examined in terms of how long

TABLE 7

Negative-Contingency Autoshaping: Summary by Trial/Cycle Ratio Over First Ten Days of Condition

SUBJ	TRIAL	CYCLE	TRIAL/CYCLE	CUM SEC PRIOR 1st RESP	CUM PAIR PRIOR TO 1st RESP	SUCC DAY RESP ON ≧ 10% TR	NO.RESP FIRST 10 DAY
A-1	6"	30"	.20	390	65	10	95
A-2	6"	30"	.20	342	57	2	34
A-3	6"	30"	.20	372	62	3	79
A-4	6"	30"	.20	156	26	4	51
A$\bar{X}$				315	52.5	4.75	64.75

SUBJ	NO.RESP/THEOR OPP	NO.RESP/ACTUAL OPP	NO.RESP/STIM PAIR	NO.RESP/T.OPP PAIR	NO.RESP/A.OPP PAIR	MAX NO. RESP	MAX NO. RESP/T.OPP
A-1	15.83	.0365	.240	.039	.0009	23	3.83
A-2	5.67	.0117	.073	.012	.000025	12	2.00
A-3	13.17	.0294	.188	.031	.00007	12	2.00
A-4	8.50	.0179	.114	.019	.00004	13	2.17
A$\bar{X}$	10.79	.0238	.153	.025	.000056	15	2.50

TABLE 7 (continued)

SUBJ	TRIAL	CYCLE	TRIAL / CYCLE	CUM SEC PRIOR 1st RESP	CUM PAIR PRIOR TO 1st RESP	SUCC DAY RESP ON ≥ 10% TR	NO.RESP FIRST 10 DAY
B-1	12"	30"	.40	1032	86	2	61
B-2	12"	30"	.40	1308	109	1	43
B-3	12"	30"	.40	12	1	0	3
B-4	12"	30"	.40	1272	106	3	61
B-$\bar{X}$				906	75.5	1.5	42.0

SUBJ	NO.RESP / THEOR OPP	NO.RESP / ACTUAL OPP	NO.RESP / STIM PAIR	NO.RESP / T.OPP / PAIR	NO.RESP / A.OPP / PAIR	MAX NO. RESP	MAX NO. RESP / T.OPP
B-1	5.08	.0110	.139	.012	.000025	20	1.67
B-2	3.58	.0074	.094	.008	.000016	10	.83
B-3	.25	.005	.006	.001	.000001	3	.25
B-4	5.08	.0109	.120	.012	.000025	22	5.08
B-$\bar{X}$	3.50	.0074	.084	.008	.000017	13.75	3.50

TABLE 7 (continued)

SUBJ	TRIAL	CYCLE	TRIAL / CYCLE	CUM SEC PRIOR 1st RESP	CUM PAIR PRIOR TO 1st RESP	SUCC DAY RESP ON ≥ 10% TR	NO.RESP FIRST 10 DAY
C-1	24"	30"	.80	2250	95	0	3
C-2	24"	30"	.80	6624	276	1	0
C-3	24"	30"	.80	10560	440	0	1
C-4	24"	30"	.80	2280	95	0	3
C-$\overline{X}$				5436	226.5	0.25	1.75

SUBJ	NO.RESP / THEOR OPP	NO.RESP / ACTUAL OPP	NO.RESP / STIM PAIR	NO.RESP / T.OPP / PAIR	NO.RESP / A.OPP / PAIR	MAX NO. RESP	MAX NO. RESP / T.OPP
C-1	.125	.00025	.006	.0003	.0000010	1	.042
C-2	.000	.00000	.000	.0000	.0000000	1	.042
C-3	.042	.0008	.002	.0001	.0000002	1	.042
C-4	.125	.00025	.006	.0003	.0000005	2	.083
C-$\overline{X}$	.073	.00014	.0035	.0002	.0000004	1.25	.052

TABLE 7 (continued)

SUBJ	TRIAL	CYCLE	TRIAL / CYCLE	CUM SEC PRIOR 1st RESP	CUM PAIR PRIOR TO 1st RESP	SUCC DAY RESP ON ≧ 10% TR	NO.RESP FIRST 10 DAY
D-1	30"	30"	1.0	30	1	1	6
D-2	30"	30"	1.0	14790	493	0	1
D-3	30"	30"	1.0	---	---	0	0
D-4	30"	30"	1.0	600	20	0	1
D-$\bar{X}$				5140	171.3	0.25	2.0

SUBJ	NO.RESP / THEOR OPP	NO.RESP / ACTUAL OPP	NO.RESP / STIM PAIR	NO.RESP / T.OPP PAIR	NO.RESP / A.OPP PAIR	MAX NO. RESP	MAX NO. RESP / T.OPP
D-1	.200	.00040	.012	.0004	.0000080	6	.200
D-2	.030	.00006	.002	.0001	.0000012	1	.030
D-3	.000	.00000	.000	.0000	.0000000	0	.000
D-4	.030	.00006	.002	.0001	.0000012	1	.030
D-$\bar{X}$	.065		.005	.0002	.0000008	2.0	.065

TABLE 7 (continued)

SUBJ	TRIAL	CYCLE	TRIAL / CYCLE	CUM SEC PRIOR TO 1st RESP	CUM PAIR PRIOR TO 1st RESP	SUCC DAY RESP ON ≥ 10% TR	NO.RESP FIRST 10 DAY
E-1	12"	60"	.20	156	13	3	59
E-2	12"	60"	.20	144	12	8	219
E-3	12"	60"	.20	0	0	1	33
E-4	12"	60"	.20	396	33	0	2
E-X̄				174		3	78.25

SUBJ	NO.RESP / THEOR OPP	NO.RESP / ACTUAL OPP	NO.RESP / STIM PAIR	NO.RESP / T.OPP / PAIR	NO.RESP / A.OPP / PAIR	MAX NO. RESP	MAX NO. RESP / T.OPP
E-1	4.92	.0106	.134	.011	.00024	14	1.17
E-2	18.25	.0595	.779	.065	.000212	47	3.92
E-3	2.75	.0059	.071	.006	.000013	19	1.58
E-4	.17	.0003	.004	.0003	.0000007	1	.08
E-X	6.52	.0191	.247	.021	.000062	20.25	1.72

TABLE 7 (continued)

SUBJ	TRIAL	CYCLE	TRIAL / CYCLE	CUM SEC PRIOR TO 1st RESP	CUM PAIR PRIOR TO 1st RESP	SUCC DAY RESP ON ≧ 10% TR	NO.RESP FIRST 10 DAY
F-1	24"	60"	.40	24	1	2	39
F-2	24"	60"	.40	24	1	1	22
F-3	24"	60"	.40	144	6	0	16
F-4	24"	60"	.40	672	28	5	61
F-$\bar{X}$				216	9	2	34.5

SUBJ	NO.RESP / THEOR OPP	NO.RESP / ACTUAL OPP	NO.RESP / STIM PAIR	NO.RESP / T.OPP / PAIR	NO. RESP / A.OPP / PAIR	MAX NO. RESP	MAX NO. RESP / T.OPP
F-1	.46	.0034	.085	.003	.000007	11	.48
F-2	.25	.0019	.046	.002	.0000039	6	.25
F-3	.17	.0014	.033	.001	.0000028	4	.17
F-4	1.50	.0061	.139	.006	.0000014	36	1.50
F-$\bar{X}$	.59	.0032	.076	.003	.0000038	14.25	.59

TABLE 7 (continued)

SUBJ	TRIAL	CYCLE	TRIAL / CYCLE	CUM SEC PRIOR TO 1st RESP	CUM PAIR PRIOR TO 1st RESP	SUCC DAY RESP ON ≧ 10% TR	NO.RESP FIRST 10 DAY
G-1	24"	120"	.20	792	33	2	37
G-2	24"	120"	.20	984	41	3	148
G-3	24"	120"	.20	2904	121	4	58
G-4	24"	120"	.20	---	---	0	0
G-X̄				1560	65	2.25	60.75

SUBJ	NO.RESP / THEOR OPP	NO.RESP / ACTUAL OPP	NO.RESP / STIM PAIR	NO.RESP. / T.OPP / PAIR	NO.RESP / A.OPP / PAIR	MAX NO. RESP	MAX NO. RESP / T.OPP
G-1	1.54	.00376	.080	.003	.000008	14	.58
G-2	6.17	.014436	.420	.017	.000041	27	1.13
G-3	2.42	.00150	.131	.011	.0000115	13	.54
G-4	.00	.00000	.000	.000	.0000000	0	.00
G-X̄	2.53	.0058	.210	.210	.000015	13.5	.56

TABLE 7 (continued)

SUBJ	TRIAL	CYCLE	TRIAL CYCLE	CUM SEC PRIOR TO 1st RESP	CUM PAIR PRIOR TO 1st RESP	SUCC DAY RESP ON ≧ 10% TR	NO.RESP FIRST 10 DAY
H-1	48"	120"	.40	8928	186	1	14
H-2	48"	120"	.40	3552	74	1	19
H-3	48"	120"	.40	240	5	0	1
H-4	48"	120"	.40	6000	125	0	2
H-$\overline{X}$				4680	97.5	.50	9

SUBJ	NO.RESP THEOR OPP	NO.RESP ACTUAL OPP	NO.RESP STIM PAIR	NO.RESP T.OPP PAIR	NO.RESP A.OPP PAIR	MAX NO. RESP	MAX NO. RESP T.OPP
H-1	.29	.00059	.033	.0006	.0000012	6	.12
H-2	.40	.00082	.039	.0008	.0000017	14	.29
H-3	.02	.000042	.002	.0000	.00000008	4	.08
H-4	.04	.000052	.004	.0001	.00000000	1	.02
H-$\overline{X}$	.19	.000038	.019	.0004	.00000075	6.25	.13

TABLE 7 (continued)

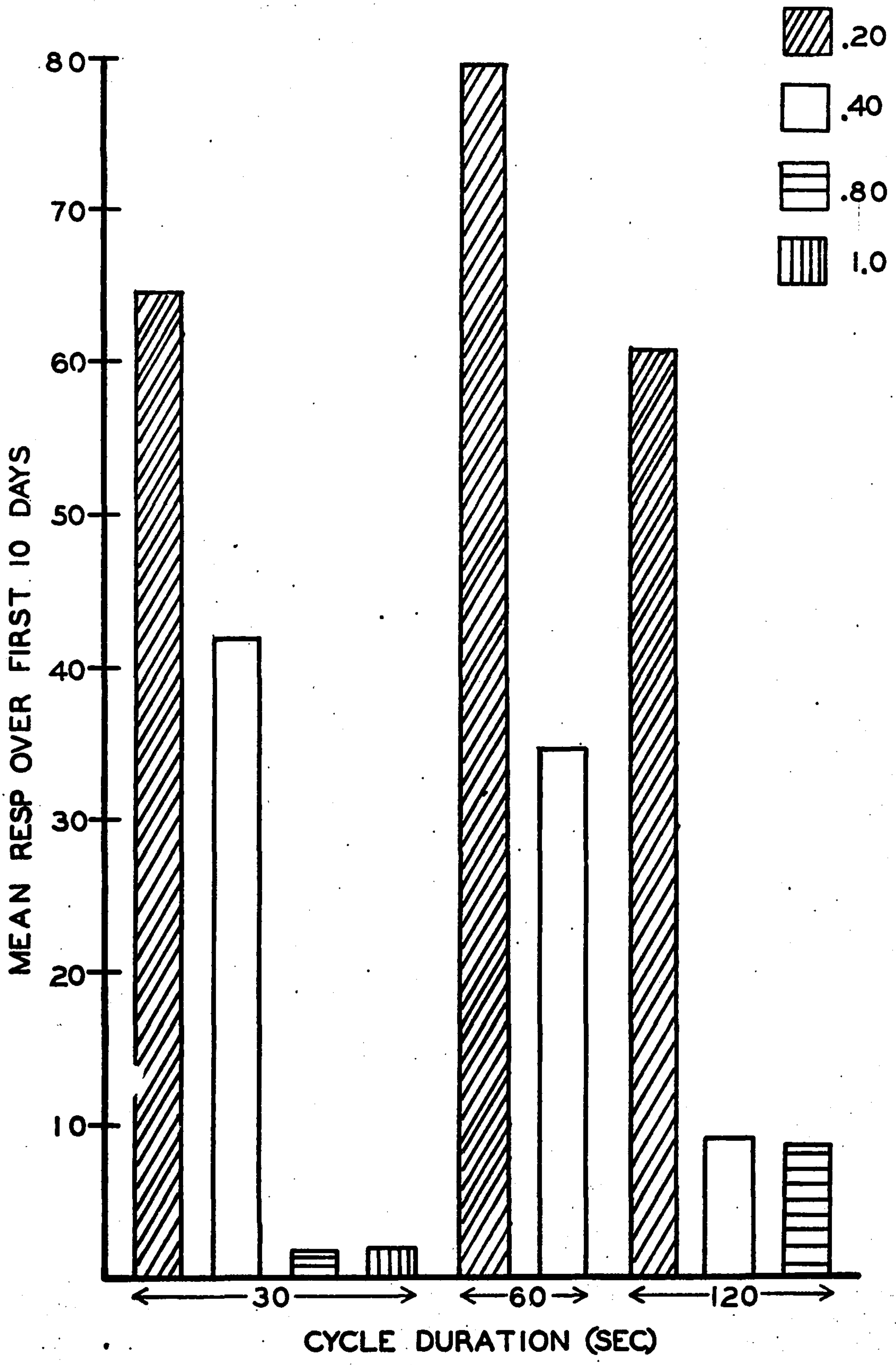
SUBJ	TRIAL	CYCLE	TRIAL / CYCLE	CUM SEC PRIOR TO 1st RESP	CUM PAIR PRIOR TO 1st RESP	SUCC DAY RESP ON ≥ 10% TR	NO.RESP FIRST 10 DAY
I-1	96"	120"	.80	27552	287	1	10
I-2	96"	120"	.80	3744	39	0	10
I-3	96"	120"	.80	960	10	1	15
I-4	96"	120"	.80	---	--	0	0
I-$\bar{X}$				10752	112	.50	8.75

SUBJ	NO.RESP / THEOR OPP	NO.RESP / ACTUAL OPP	NO.RESP / STIM PAIR	NO.RESP / T.OPP PAIR	NO.RESP / A.OPP PAIR	MAX NO. RESP	MAX NO. RESP / T.OPP
I-1	.10	.000210	.020	.0002	.0000004	5	.05
I-2	.10	.000210	.020	.0002	.0000004	2	.02
I-3	.16	.000318	.031	.0003	.0000007	7	.07
I-4	.00	.000000	.000	.0000	.00000000	0	.00
I-$\bar{X}$	.04	.00018	.024	.0002	.00000037	3.5	.03

it takes for the production of the first response, but for the moment these data will be bypassed. In terms of whether or not responding occurred at all, it can be seen from Table 7 that only one bird (G-4) in all of the three 20% groups failed to make at least one response over the first ten days (one out of twelve: 8.3%). All of the 40% birds made at least one response. Two out of eight (25%) 80% subjects never made a response. One out of four 100% subjects (25%) never made a response. It appears then, that, generally, the smaller ratio birds were more likely to respond than the birds on the longer ratio conditions. In terms of maintenance at greater than or equal to 10% of the daily trials, two of the twelve 20% birds failed to reach this criterion (16.7%), two of eight 40% birds (25%), five of eight 80% birds (62.5%), and three of four 100% birds (75%).

Figure 17 shows the mean number of responses cumulated over the first ten days of the initial condition, plotted as a function of cycle values broken down into the various percentages of the cycle occupied by the trial stimulus. Each bar represents the mean of the four birds run under that condition. Data for the birds which did not respond are included as zero amount of responding. Outstanding for all three cycle values is the fact that most responding occurred under the 20% condition. Second most responding occurred under the second lowest percentage, the 40% conditions. Both the 80% and 100% groups are

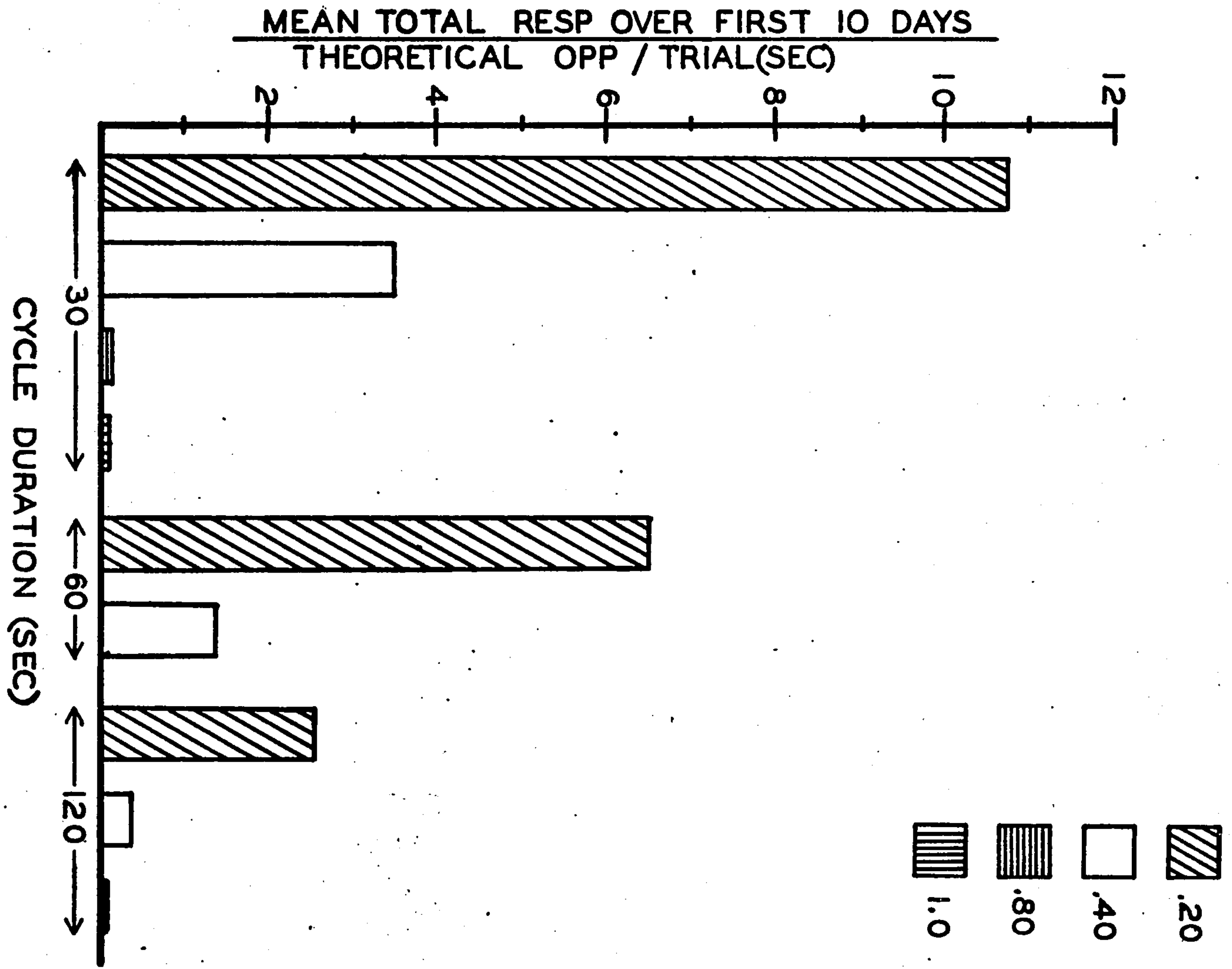
Figure 17. Mean no. of responses recorded over the first ten days of the initial negative-contingency condition, plotted as a function of increasing trial/cycle ratio within each cycle duration.


.20
.40
.80
1.0
MEAN RESP OVER FIRST 10 DAYS
80
70
60
50
40
30
20
10
30
60
120
CYCLE DURATION (SEC)

substantially lower than the 20% and 40% groups for the 30-sec cycle, but for the 120-sec cycle there is not a lot of difference between the 40% and 80% groups. Across cycle values, the three 20% groups do not seem to be systematically related to cycle size. The 40% groups, however, reflect a decreasing number of responses as the value of the cycle size increases. The data for the 120-sec cycle are considerably lower than for either the 30-sec or 60-sec cycle.

These data appear orderly, then, in the sense that it is generally under the smaller ratio conditions that most responding is observed, and this is true regardless of the value of the overall cycle. In several ways, however, these data may be considered to be biased. As in the previous examination of absolute trial and cycle effects, the "opportunity" factor can still be taken into account here. The birds on the shorter condition have time against them when being compared to birds which have as many as 16 times as many available sec of trial time in which to respond. Corrections can be made in either "theoretical" opportunity or "actual" opportunity. Figure 18 shows the number of responses totaled over the first ten days and corrected for all the theoretically available trial time, plotted as a function of the cycle values broken down into the various ratio groups. As in the uncorrected figure (Figure 17), the strong effect of the percentage of the cycle occupied by the trial is obvious. Whether the cycle value is

Figure 18. Mean no. of responses recorded over the first ten days of the initial negative-contingency condition, corrected for theoretical opportunity to respond (see text), and plotted as a function of increasing trial/cycle ratio within each overall cycle duration.

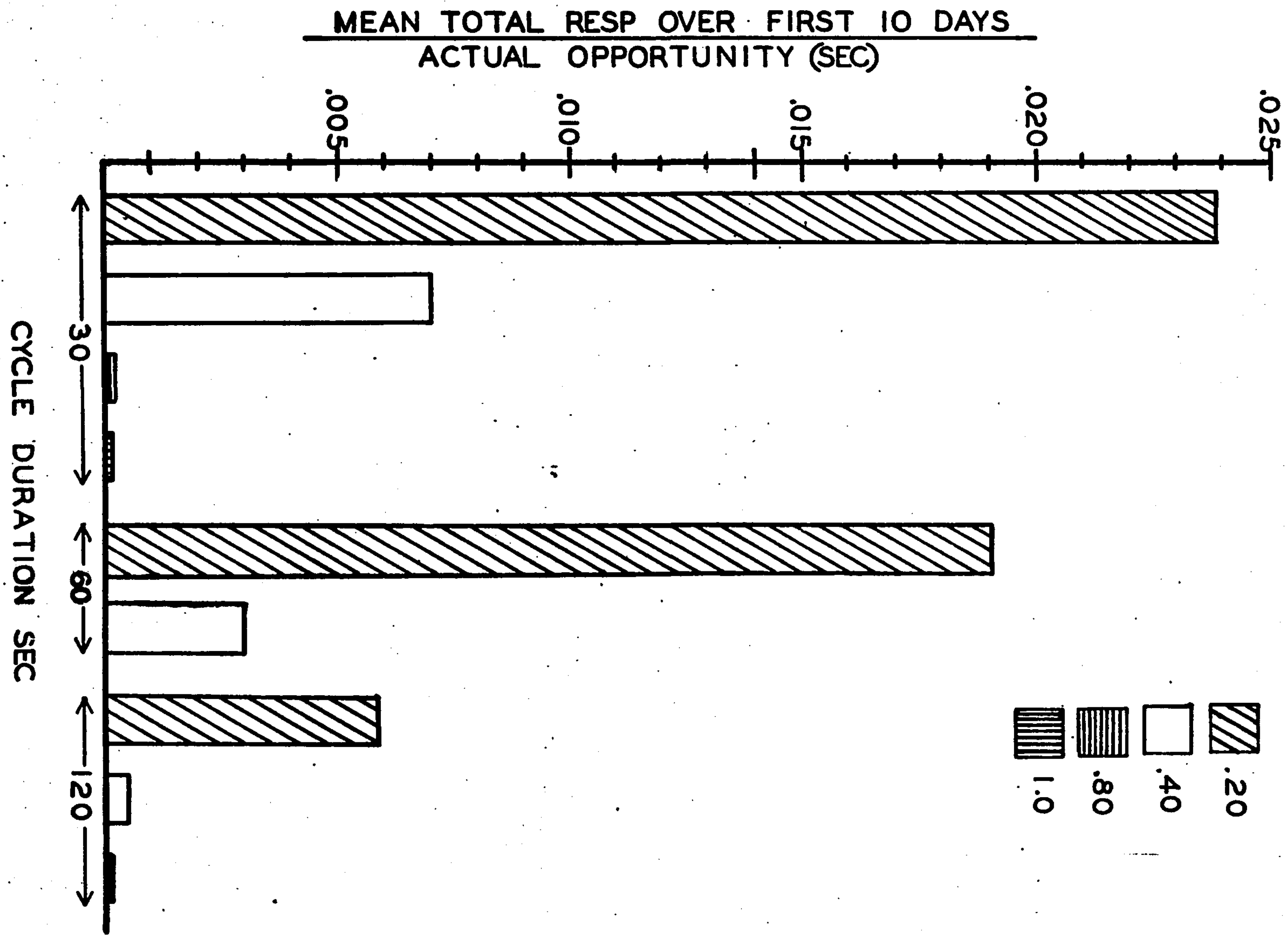

MEAN TOTAL RESP OVER FIRST 10 DAYS
THEORETICAL OPP / TRIAL(SEC)
2
4
6
8
10
12
30
60
120
CYCLE DURATION (SEC)
.20
.40
.80
1.0

30-sec, 60-sec, or 120-sec, the 20% trial value is still the occasion for the most responding. Likewise, the next most responding for all three cycles occurred under the 40% condition. For the cycles with an 80% group, this 80% group was still lower than the 40% group, and for the 30-sec cycle, in which there was a 100% group, this 100% group was lower still than the 80% group.

In addition to this trial/cycle effect, however, another relationship can now be seen. In Figure 17 it was pointed out that the 40% groups across cycle values reflected a decreasing number of responses as the value of the cycle size increased. The same thing can now be seen in Figure 18 for the 20% groups. Not only is the 20% ratio the most effective ratio across all cycle values, it is more effective under the 30-sec cycle than under the 60-sec cycle, in which it is, in turn, more effective than under the 120-sec cycle. The same is true for the 80% ratios and for the 40% ratios, except for a slight reversal for the latter between the 60- and 120-sec cycles.

If the actual opportunity is corrected for, as in Figure 19, the same relationships can be seen. Consistently within each cycle, the amount of responding is a decreasing function of the percentage of the cycle occupied by the trial stimulus. Over cycles, the amount of responding for any given ratio is generally a decreasing function of the value of the total cycle. The 40% groups for the

Figure 19. Mean no. of responses recorded over the first ten days of the initial negative-contingency condition, corrected for the actual no. of sec for which the key was lighted, and plotted as a function of increasing trial/cycle ratio within each overall cycle duration.


MEAN TOTAL RESP OVER FIRST 10 DAYS
ACTUAL OPPORTUNITY (SEC)
.005
.010
.015
.020
.025
CYCLE DURATION SEC
30
60
120
.20
.40
.80
1.0

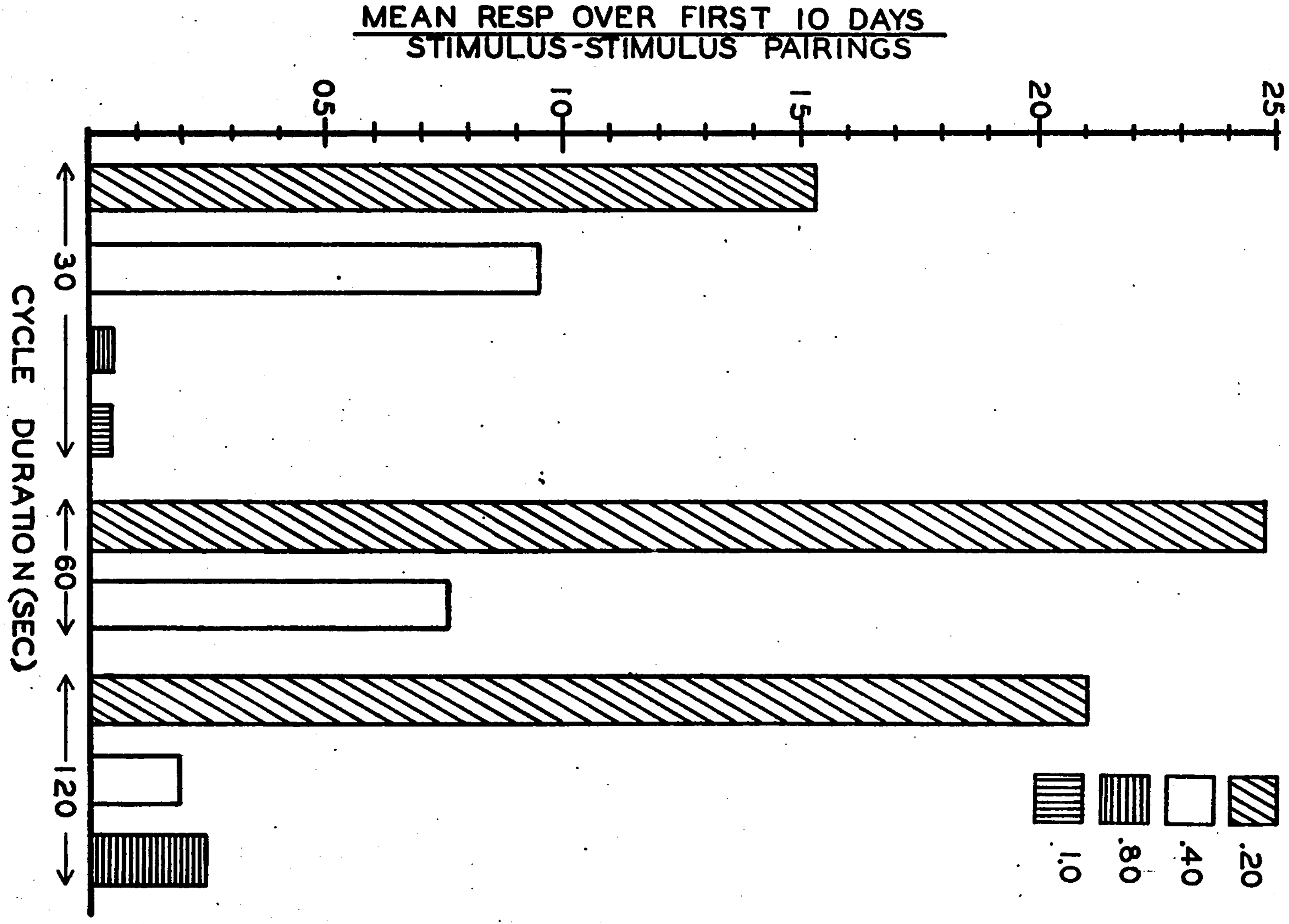
60- and 120-sec cycles no longer appear to be reversed in this figure. The 80% group for the 30-sec cycle is slightly lower than for the 80% group in the 120-sec cycle, but the values for both groups are so low that the difference is probably unimportant.

With this new information in mind, the previous figures relating to effects of trial stimulus alone and cycle value alone can be re-examined. Looking again at Figure 2, it is now reasonable that the 30-sec stimulus group required more pairings prior to the first response when compared to 48- and 96-sec groups. For the 30-sec stimulus group, the cycle value also was 30-sec, rendering the ratio between trial and cycle 100%. It is not surprising that one of the four birds in this group never made a response and that for those birds which did respond, acquisition was generally slow and maintenance reached the criterion of responses on greater than or equal to 10% of the daily trials for only one of the four. Looking at the rest of Figure 2, the 6-sec group was comprised totally of 20% ratio birds, the 12-sec group was comprised of four 20% ratio birds and four 40% birds, all in the range of ratios which have been seen to support the most responding within a given cycle value. The 24-sec stimulus birds include 20%, 40% and 80% ratio birds, the 48-sec birds are all 40% birds, and the 96-sec group is comprised of only 80% birds. Similar types of analyses can be done for Figures 3-6. In every case, a knowledge of the operation of the ratio effect and the "cycle" effect makes clear why the groups did not always line up systematically as a function of trial size itself.

The results for the effect of cycle size are also clearer now. The 60-sec cycle birds consisted entirely of birds in groups with either a 20% trial/cycle ratio or a 40% trial/cycle ratio; in either case acquisition would be expected to be rapid and maintenance high, on the basis of what was seen in Figures 17, 18 and 19. The 30-sec cycle included ratios of 80% and 100%, which have been seen to always occasion the lowest responding. The 120-sec cycle did not have a 100% ratio group, but did include the high 80% ratio. Also, Figures 17-19 indicate that the longer the absolute duration of the cycle, the lower the responding observed under any given ratio value.

There are some reasons to suspect that corrections such as these by theoretical or actual opportunity are somewhat overdone, and these problems will be evaluated in the discussion section of this paper. A strong argument can be made, however, for weighting the raw number of responses by some kind of correction factor which takes time into account. But even given that some sort of opportunity factor is taken into account, there is another sense in which the data might appropriately be weighted. In the negative contingency procedure, every time a response is directed at the keylight, the keylight is terminated, and no grain is available at the end of the trial period. As a consequence of the negative contingency, then, the very factor which presumably is operating to produce the keypeck (the pairing of keylight and grain) is precluded any time that it effectively does produce a response. In the present study, therefore, the birds which were making the most keypecks were also being biased against pecking by the fact that stimulus-stimulus pairings were being reduced. A way to take this factor into account would be to weight the non-pairings (in other words, response trials) by the pairings (non-response trials). This has been done in Figure 20, which shows the mean number of responses totaled over the first 10 days divided by the total number of stimulus-stimulus pairings presented over the first ten days, plotted once again as a function of the overall cycles broken down into the various trial/cycle ratios. The figure looks similar to those of the number of responses over the first ten days before correction for opportunity to respond. The main effect of the trial/cycle ratio is still apparent, although there was more responding on the 80% condition than the 40% condition at the 120-sec cycle. Within ratios across cycle values, however, responses do not clearly decrease as a function of increasing

Figure 20. Mean no. of responses recorded over the first ten days of the initial negative-contingency condition, corrected for the actual no. of keylight-grain pairings for the same period, and plotted as a function of increasing trial/cycle ratio within each overall cycle duration.


MEAN RESP OVER FIRST 10 DAYS
STIMULUS-STIMULUS PAIRINGS
05
10
15
20
25
CYCLE DURATION (SEC)
30
60
120
1.0
.80
.40
.20

cycle values. Such an effect can be seen in the 40% groups, perhaps, but not for all groups as in Figure 19.

In this figure, of course, the correction for opportunity has not been made. When corrected for theoretical opportunity, as in Figure 21, the cycle value effect can be seen once again. Not only are the groups within each cycle value "appropriately" aligned with respect to trial/cycle ratio, but, also, the responding within the respective trial/cycle ratios can again be seen to be a decreasing function of increases in cycle value. There is actually little difference in the figure for the 40% ratios at the 60-sec and 120-sec cycles, and in the 80% and 100% ratios within the 30-sec cycle, but the figures at these values are again so small that the clearest observation is with respect to the large differences between the 20% and 40% groups and the 80% and 100% groups. When the same data are corrected for actual opportunity as well as number of stimulus-stimulus pairings, as in Figure 22, the differences in the 40% groups at the various cycles are correctly aligned, but the differences are again very small.

The trial/cycle ratio effect can also be examined in terms of how long it takes for the production of the first response. Figure 23 shows the mean and median number of pairings prior to the first response for the three

Figure 21. Mean no. of responses recorded over the first ten days of the initial negative-contingency condition, corrected for both theoretical opportunity and actual no. of keylight-grain pairings over the same time period, and plotted as a function of increasing trial/cycle ratio within each overall cycle duration.

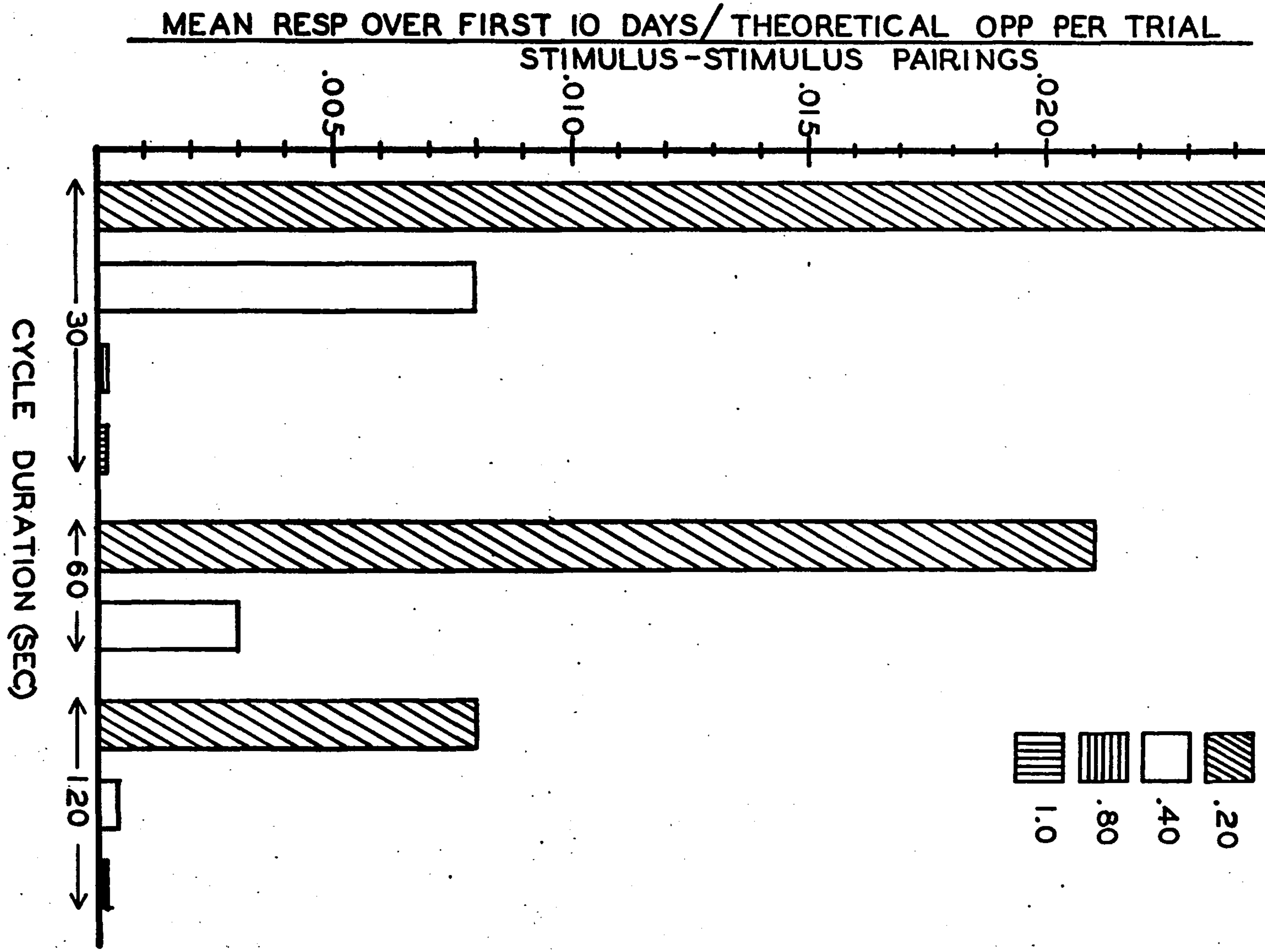

MEAN RESP OVER FIRST 10 DAYS/THEORETICAL OPP PER TRIAL
STIMULUS-STIMULUS PAIRINGS
.005
.010
.015
.020
.025
CYCLE DURATION (SEC)
30
60
120
1.0
.80
.40
.20

Figure 22. Mean no. of responses recorded over the first ten days of the initial negative-contingency condition, corrected for both actual no. of sec for which the key was light and actual no. of keylight-grain pairings over the same period, and plotted as a function of increasing trial/cycle ratio within each overall cycle duration.

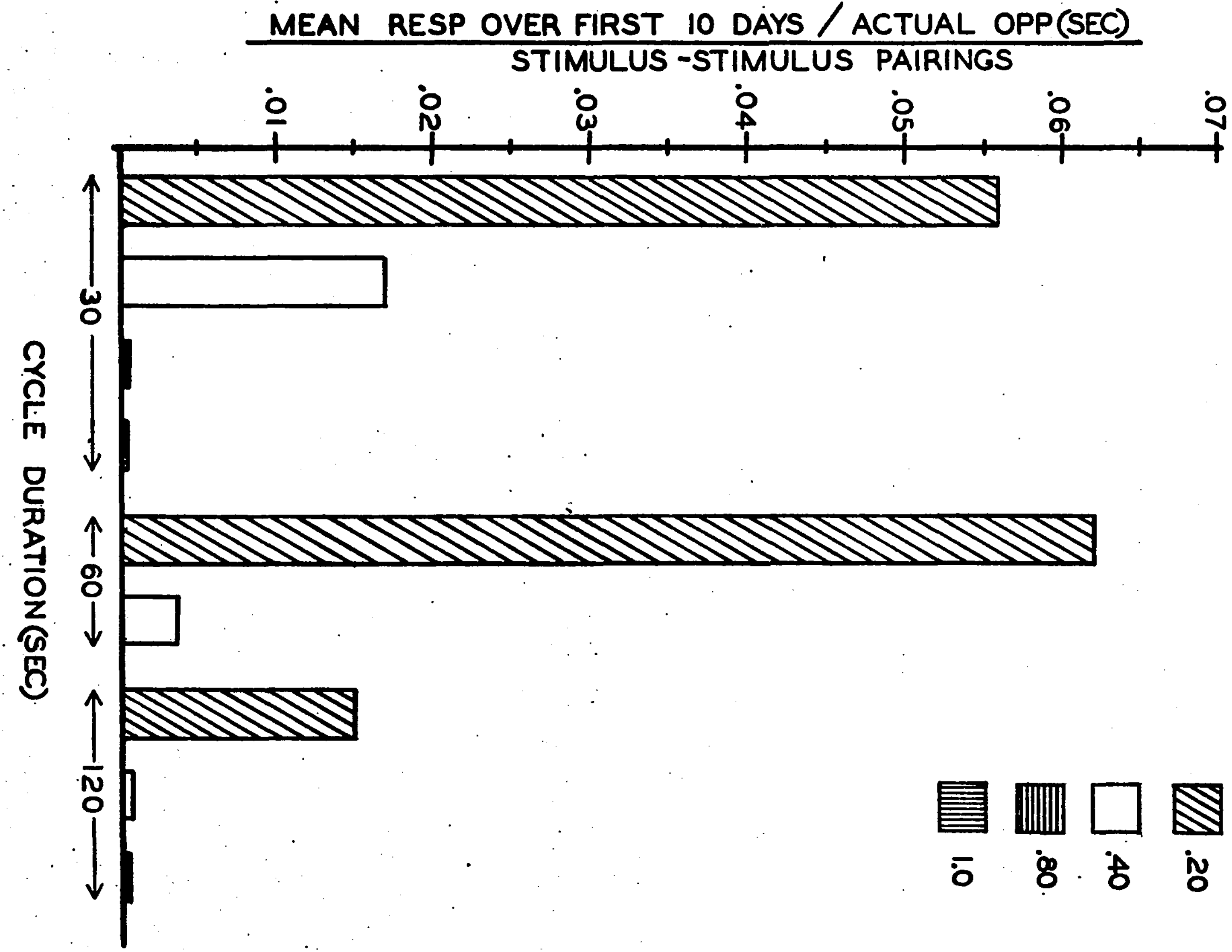
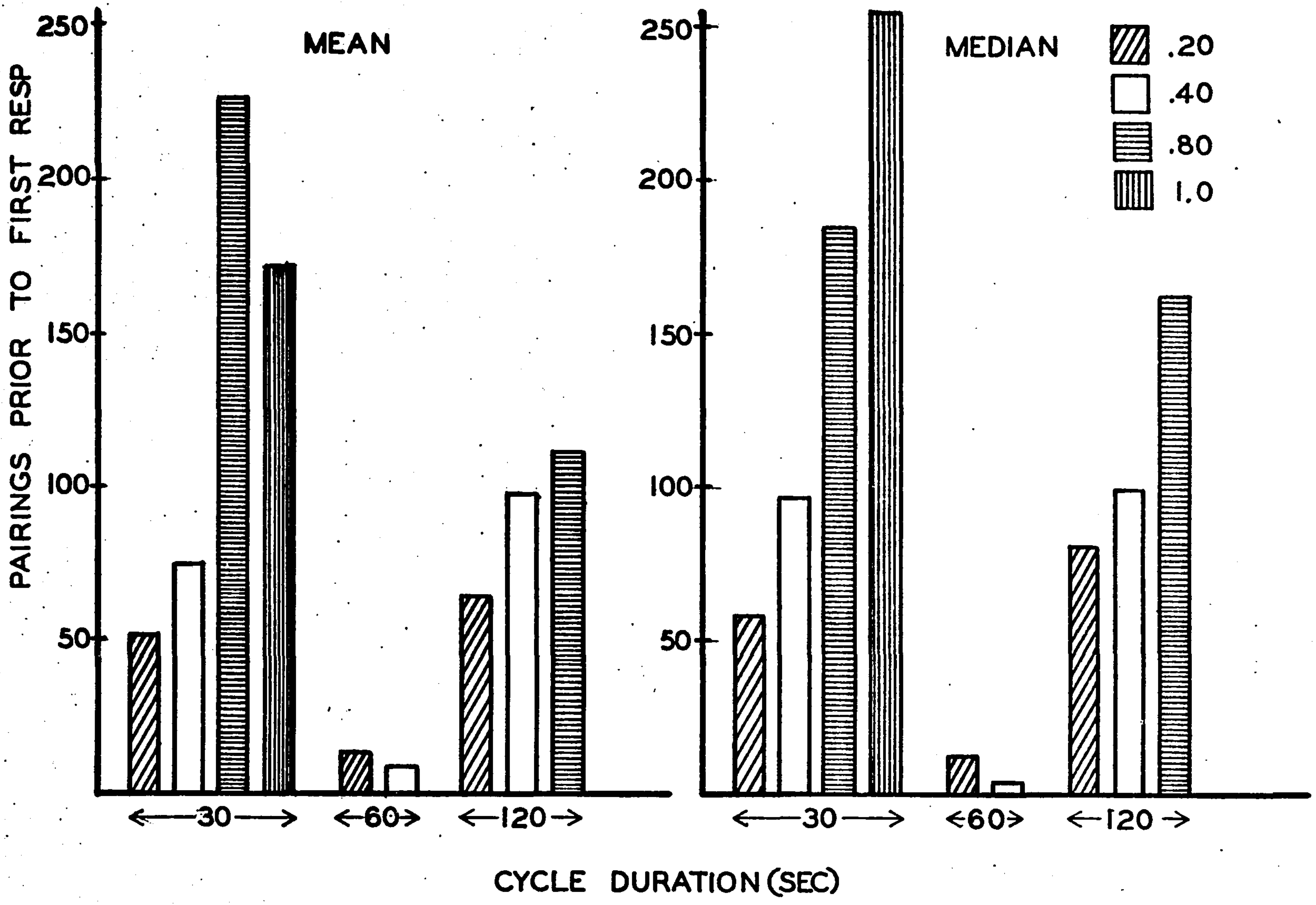

MEAN RESP OVER FIRST 10 DAYS / ACTUAL OPP(SEC)
STIMULUS-STIMULUS PAIRINGS
.01
.02
.03
.04
.05
.06
.07
30
60
120
CYCLE DURATION(SEC)
.20
.40
.80
1.0

Figure 23. Mean and median no. of keylight-grain pairings prior to the occurrence of the first keypeck, plotted as a function of increasing trial/cycle ratio within each specific absolute cycle duration.

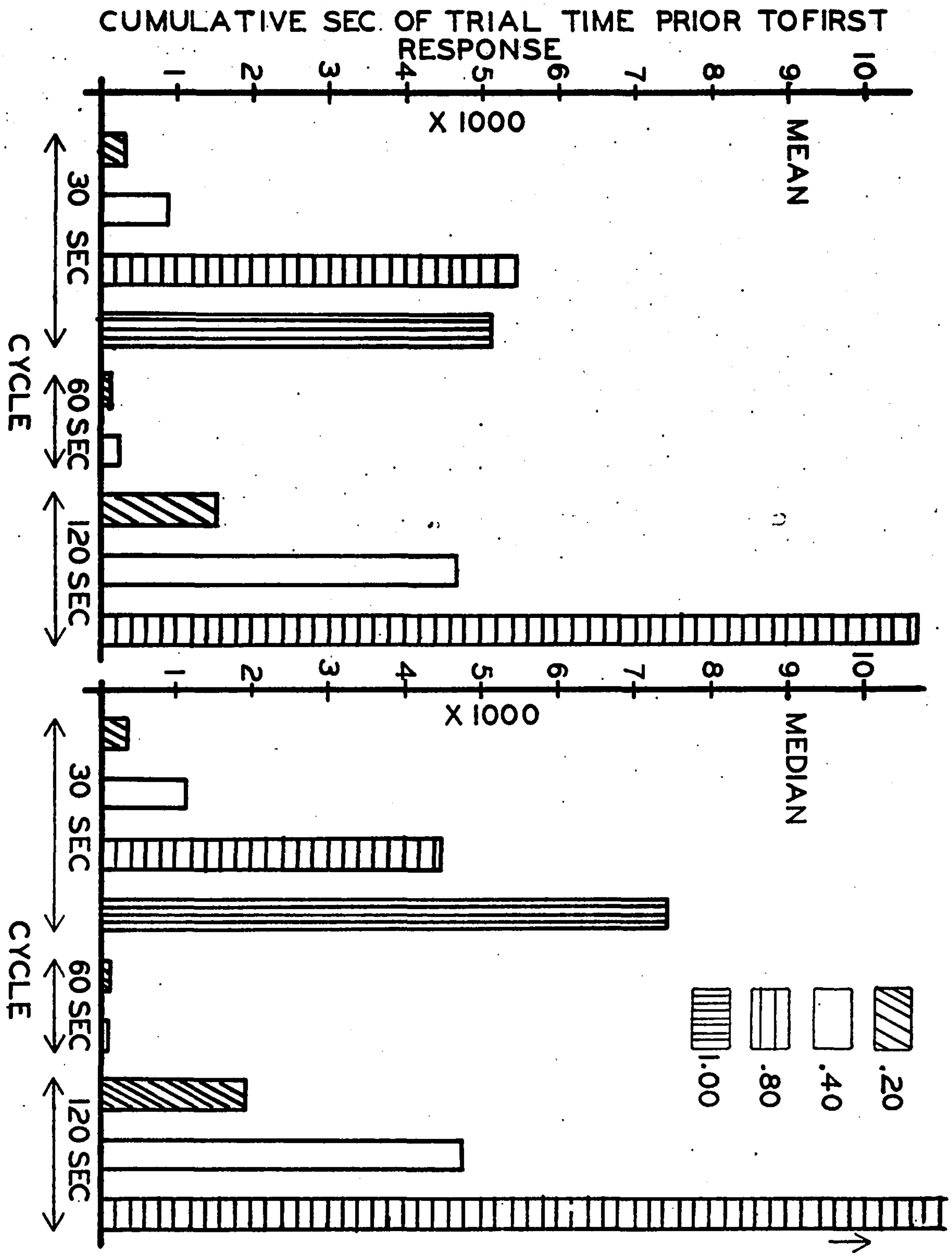

MEAN
MEDIAN
PAIRINGS PRIOR TO FIRST RESP
250
200
150
100
50
← 30 →
← 60 →
← 120 →
CYCLE DURATION (SEC)
▨ .20
☐ .40
▤ .80
▥ 1.0

cycle values broken down into trial/cycle ratios. For the mean data, in the 30-sec cycle a generally increasing function is seen as the trial/cycle ratio increases, although the number of pairings for the 100% group are lower than would be expected on the basis of previously presented data. An examination of the data for these 30-sec cycle, 100% trial birds, given individually in Table 7, will suggest why this particular group appears a little out of line. In this group, one bird took an extremely large number of pairings before coming to peck the key, another never pecked the key at all. The bird which never pecked is not included in the computation of the mean for this group, so the real effect of the 100% group is not as strongly represented as it might be. Additionally, it can also be seen from Table 7 that one pigeon in this group pecked the trial light after only one pairing trial. On the basis of the data from the majority of birds, it is unlikely that pecking is this rapidly educed by the pairing of the key and grain. This bird's early keypeck, therefore, is more likely a function of orientation to novel stimuli, the pigeon's tendency to peck bright things, etc., rather than a function of the relationship between the keylight and the grain.

For the 60-sec cycle, the mean data are also somewhat lower relative to those for the 30-sec cycle than would be expected. Once again, an examination of the individual data in Table 7 suggests why these figures are so low. In the 60-sec, 20% group, one bird made a keypeck the very _first_ time the keylight came on. This peck is obviously not the result of pairings between light and grain, since no pairings had yet occurred. The number of pairings prior to the first response for the other three birds under this condition are 13, 12, and 33, which probably are more representative of the effectiveness of the pairings given that particular cycle and ratio. Likewise, for the 60-sec, 40% birds, two can be seen to have pecked the key on the second trial, again probably not as a function of light grain pairings. These four birds just mentioned are the only birds which pecked the key so rapidly except for one other bird in the 30-sec, 40% group. The data for the 120-sec birds appear to conform with what has generally been the effect of the trial/cycle value. For the median data, the birds which pecked almost immediately still show their influence in the data for the 60-sec cycle, which are unusually low. Notice again that the 20% and 40% birds required fewer pairings prior to the first response when the overall cycle was 30 sec than when it was 120 sec.

Presentation of the mean or median number of pairings prior to the first response is, of course, still biased by the differential opportunities to respond represented by the various stimulus durations. A correction for this opportunity is (as has been seen) to present the cumulative sec of trial time prior to the first response. These data are shown in Figure 24. For the mean data, the ratio effect can readily be seen in all cycles. In the 30-sec cycle, the 100% group would be expected to require the greatest amount of time prior to the first response, but in the figure, the 80% group can be seen to actually require more time than the 100% group. This difference once again probably reflects the fact that the "worst" 100% bird (the one which did not respond at all) is not included in the computation of the mean. Looking at the median data for a moment, in which that bird _is_ included, the 100% group is now aligned with the 80% group as in previous figures. The birds which responded so early drastically bring down the means and medians for the birds in the 60-sec cycle condition. Other than this low 60-sec condition, however, the values are pretty well in line with what would be expected from the effect of the ratio and cycle values: the smaller ratio birds generally required fewer pairings of key and grain and fewer sec of cumulated trial time prior to the first response, and the same ratio generally required more pairings and trial time prior to the first response the larger the value of the overall cycle.

Figure 24. Mean and median no. of sec of trial time (keylight on) cumulated prior to the occurrence of the first recorded keypeck, plotted as a function of increasing trial/cycle ratio within each absolute cycle duration.


CUMULATIVE SEC. OF TRIAL TIME PRIOR TOFIRST RESPONSE
1
2
3
4
5
6
7
8
9
10
X 1000
MEAN
MEDIAN
30 SEC
60 SEC
120 SEC
CYCLE
1.00
.80
.40
.20

There are other dependent measures which support the same conclusions. One such measure, already presented for absolute trial value alone and for absolute cycle value alone, is the maximum number of responses recorded on any one session over the first ten days. These mean data are presented in Figure 25. Within a cycle value, the effect of the trial/cycle ratio is very clear. As the value of the trial/cycle ratio increases, maximum responding decreases. With the exception of a slight reversal in the 80% and 100% groups (both of which are very low), this relationship holds within the 30-sec, 60-sec and 120-sec groups. If these same data are corrected for theoretical opportunity to respond on any given trial, then the data look as represented in Figure 26. Here again the effect of the ratio is evident within each cycle value. In addition, across cycle values, the value for any given ratio can be seen to decrease as the value of the cycle increases.

If the mean successive days on which responding was maintained at equal to or greater than 10% of the daily trials is examined, as in Figure 27, the ratio effect is again clear. Within each cycle value, days maintained at greater than or equal to 10% decreases as the value of the ratio increases. The cycle value effect can also be seen but not as consistently. For the 20% groups, it is clear that more responding was maintained longer when the cycle

Figure 25. Mean maximum responses recorded for any one session, plotted as a function of increasing trial/cycle ratio within each absolute cycle duration.

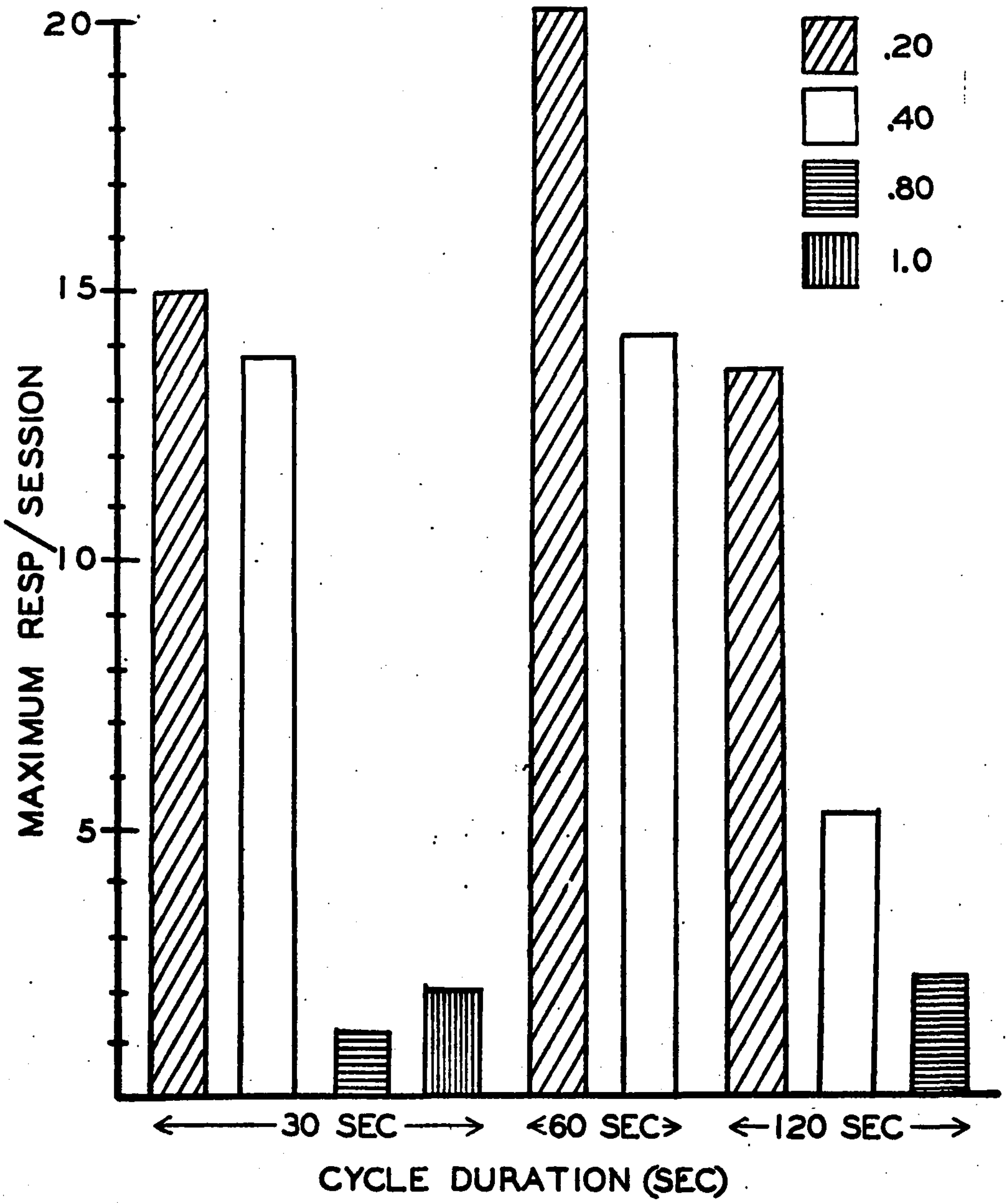

MAXIMUM RESP/SESSION
20
15
10
5
.20
.40
.80
1.0
30 SEC
60 SEC
120 SEC
CYCLE DURATION (SEC)

Figure 26. Mean maximum responses recorded for any one session over the first ten days of the initial negative-contingency condition, corrected for theoretical opportunity per trial (see text), and plotted as a function of increasing trial/cycle ratio within each overall cycle duration.

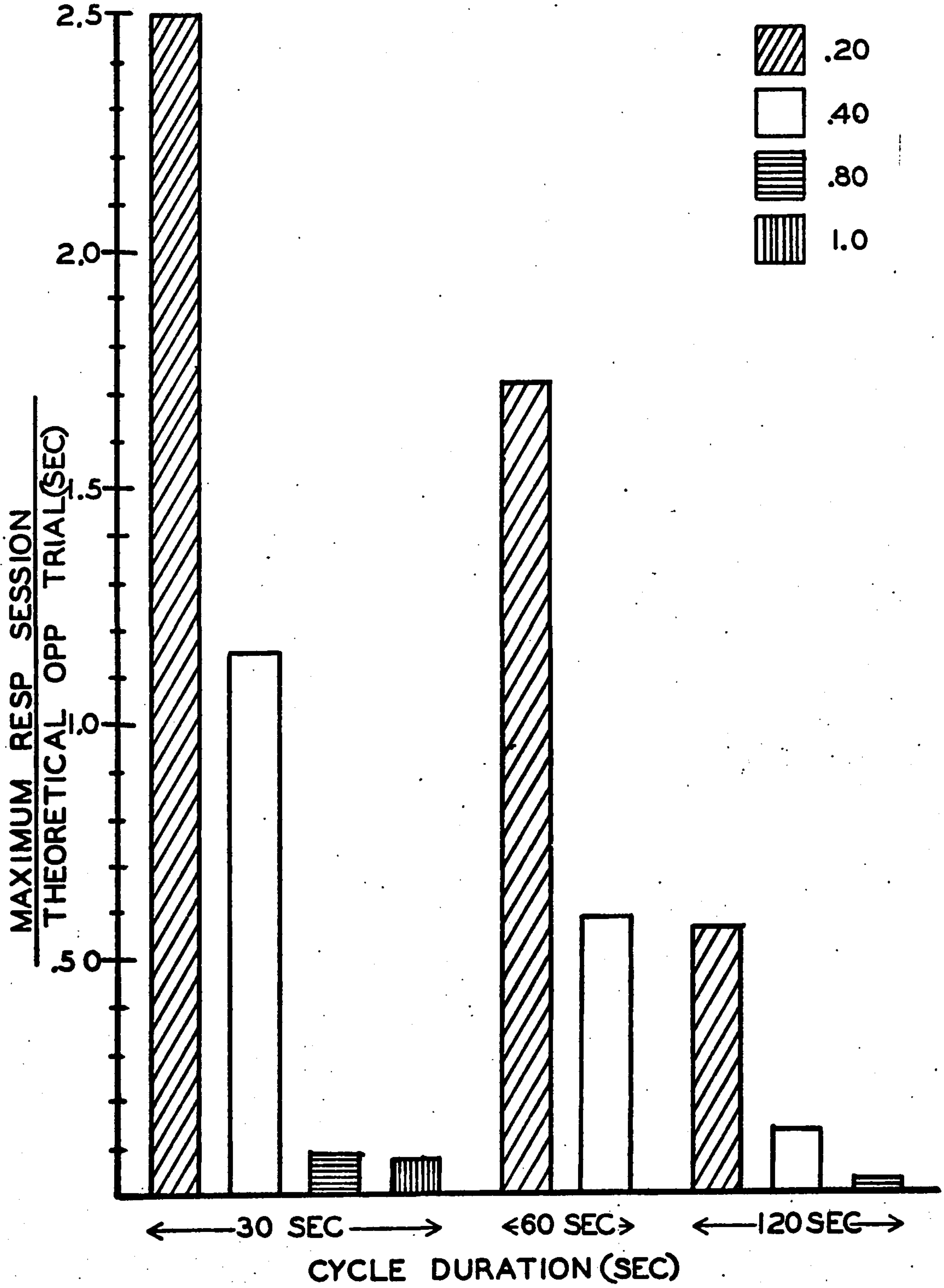
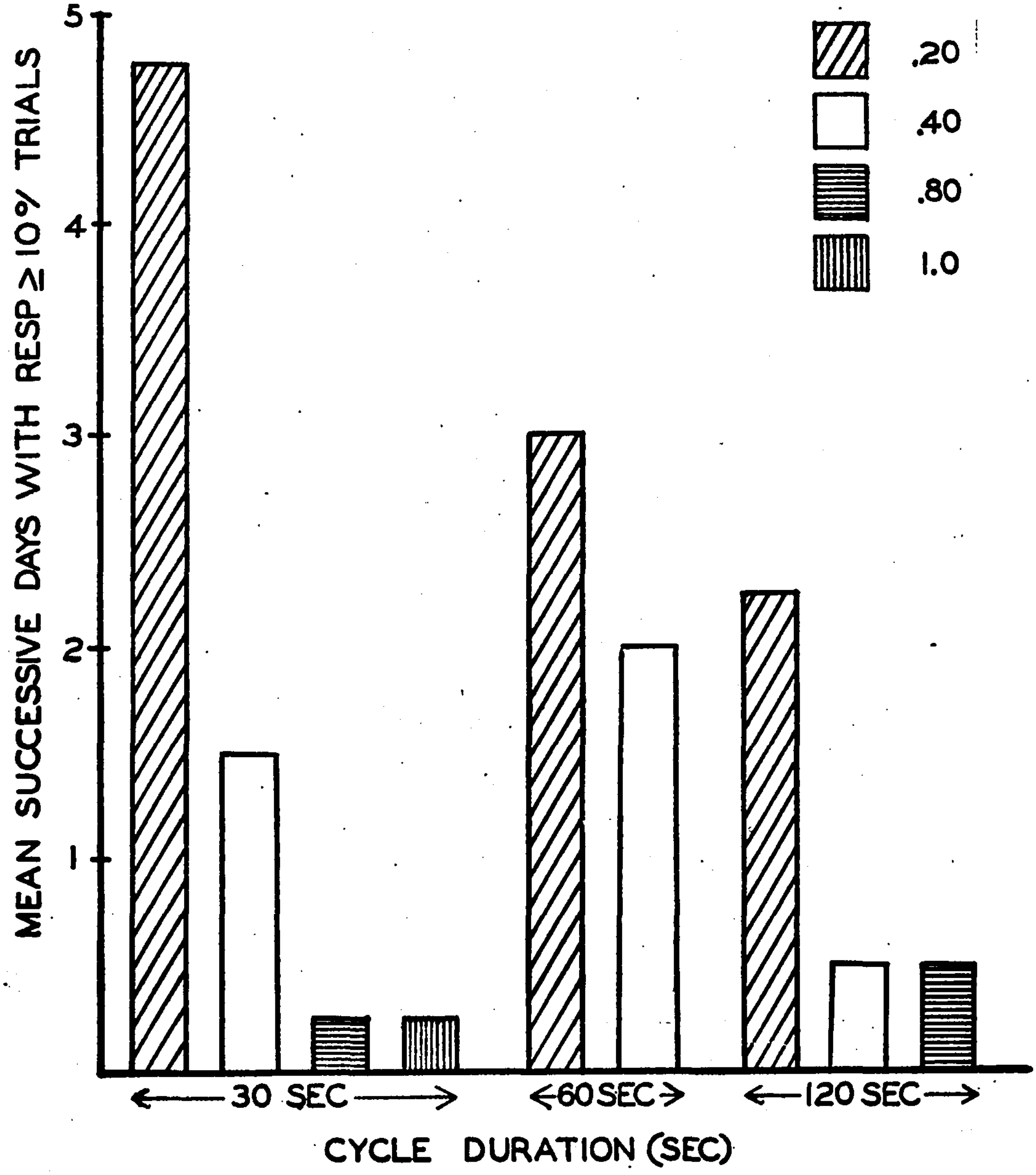

MAXIMUM RESP SESSION
THEORETICAL OPP TRIAL (SEC)
2.5
2.0
1.5
1.0
.50
.20
.40
.80
1.0
30 SEC
60 SEC
120 SEC
CYCLE DURATION (SEC)

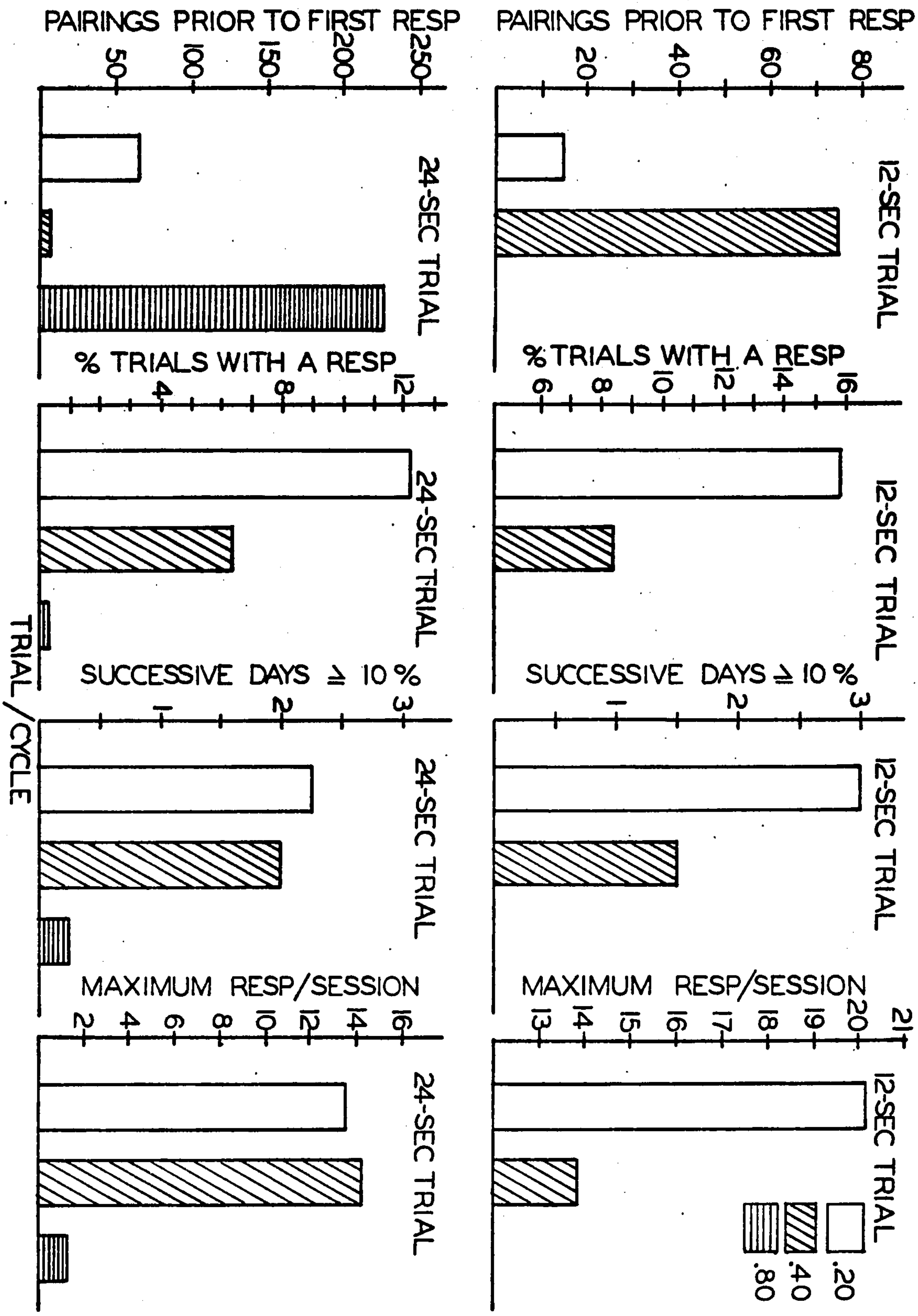
Figure 27. Mean no. of successive days on which responding was maintained on equal to or greater than 10% of the daily trials, plotted as a function of increasing trial/cycle ratio within each overall cycle duration.


MEAN SUCCESSIVE DAYS WITH RESP ≥ 10% TRIALS
5
4
3
2
1
.20
.40
.80
1.0
30 SEC
60 SEC
120 SEC
CYCLE DURATION (SEC)

value was 30 sec than for a cycle value of 60 sec, which in turn maintained more responding than a cycle value of 120 sec. The 40% groups are not as clear, as maintenance is longer for this ratio at the 60-sec cycle than at the 30-sec cycle. Values are very small here, however, so the difference of half a session is not very great.

It has been shown consistently throughout these measures that the acquisition and maintenance of the pecking response is related to the proportion of the cycle occupied by the trial stimulus as well as the absolute value of the overall cycle. The groups from this negative contingency design which had equal trial durations can now be compared when those values vary in their ratio value. In Figure 28, two 12-sec trial stimuli are compared for several measures, and three 24-sec stimuli are compared for several measures. For example, in the top left-hand corner of the figure, number of pairings prior to the first response are presented for two 12-sec trial stimulus groups (N=4 for each group). It can easily be seen that the pecking response was acquired much faster under a 12-sec stimulus if that stimulus was only lighted 20% of the time rather than lighted 40% of the time. Likewise, progressing to the right, across the upper portion of this figure, the 12-sec stimulus group whose trial/cycle ratio was 20% also responded on a higher percentage of the trials, responded on greater than or equal to 10% of the daily trials longer, and reached a

Figure 28. Comparison of two 12-sec trial durations and three 24-sec trial durations on four dependent measures: mean pairings prior to the first recorded keypeck, mean percent trials with a response, mean no. of successive days with responding on at least 10% of the daily trials, and mean maximum responses recorded for any one session.


PAIRINGS PRIOR TO FIRST RESP
20
40
60
80
12-SEC TRIAL
PAIRINGS PRIOR TO FIRST RESP
50
100
150
200
250
24-SEC TRIAL
% TRIALS WITH A RESP
6
8
10
12
14
16
12-SEC TRIAL
% TRIALS WITH A RESP
4
8
12
24-SEC TRIAL
SUCCESSIVE DAYS ≥ 10 %
1
2
3
12-SEC TRIAL
SUCCESSIVE DAYS ≥ 10 %
1
2
3
24-SEC TRIAL
MAXIMUM RESP/SESSION
13
14
15
16
17
18
19
20
21
12-SEC TRIAL
MAXIMUM RESP/SESSION
2
4
6
8
10
12
14
16
24-SEC TRIAL
TRIAL/CYCLE
.20
.40
.80

higher point of maximal responding, than did the group with a 12-sec stimulus when that stimulus comprised 40% of the total cycle. The same data are presented in the lower portion of the figure for all three groups which were run with a trial stimulus of 24 sec. The ratios for these groups were 20%, 40%, and 80%. Number of pairings prior to the first response is aligned as would be expected, except that the 40% group achieved pecking faster than did the 20% group. As already pointed out from Table 7, these 60-sec cycle, 40% trial ratio birds included two birds which pecked too early for those pecks to be considered engendered by the pairing procedure. With respect to percentage of the daily trials on which a response occurred, the 20% group shows more trial responses than does the 40% group, which again shows more responding than does the 80% group. The same is true with respect to number of successive days at greater than or equal to 10% of the daily trials. Maximum responses on any one session again show the 40% birds showing more peck responding than the 20% birds, but both of these groups are substantially higher than the 80% group.

Group comparisons consistently show two variables of which the amount of responding observed on the negative contingency is a function: ratio of trial/cycle, and absolute cycle value. If responding was maintained in individual birds for a period of days or weeks, these same effects should be demonstrable in individual subjects.

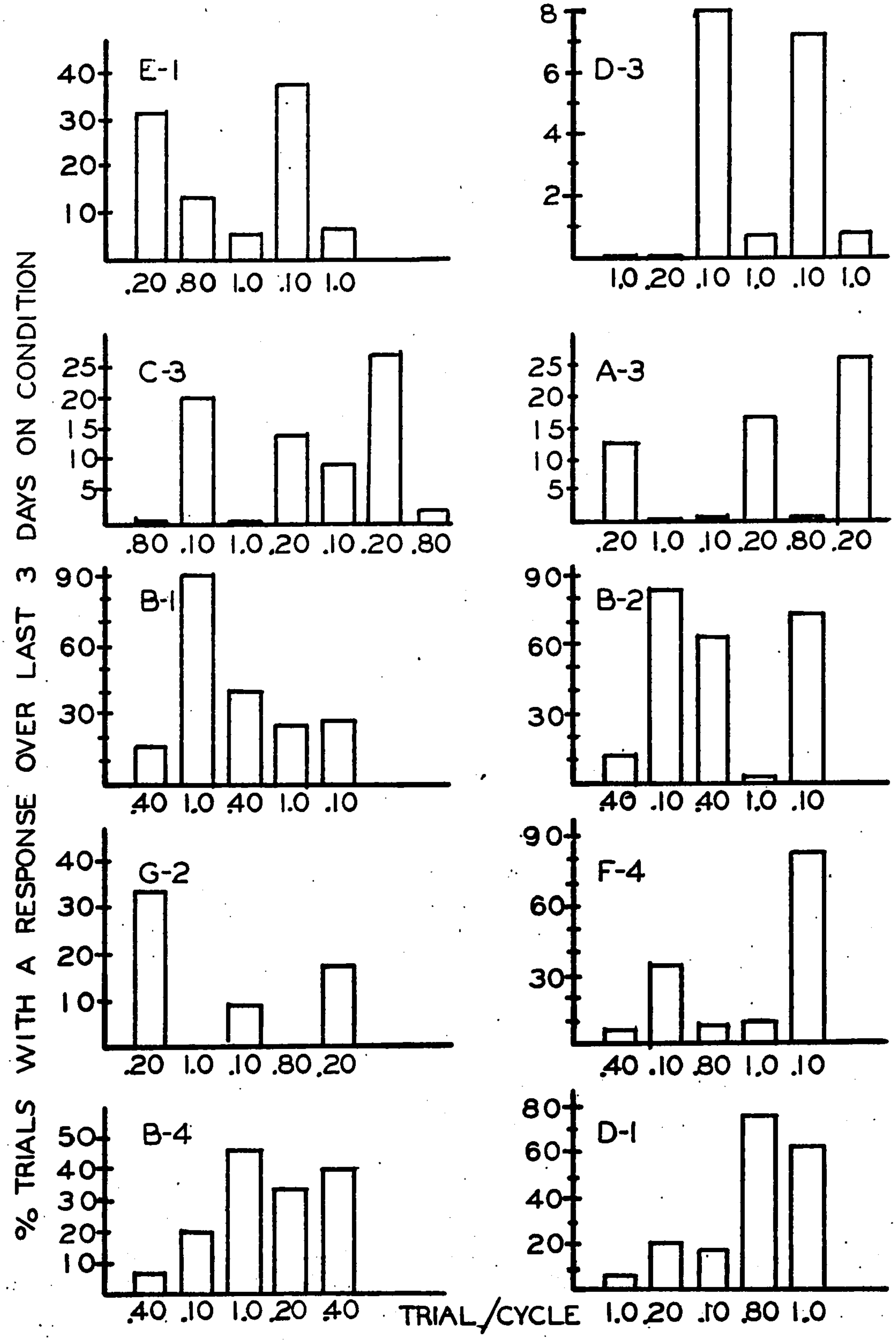
Individual manipulations: As pointed out earlier, responding on the negative contingency has been consistently observed, at least within this laboratory, to be a relatively short-lived phenomenon. Individual birds have differed with respect to peak responding obtained and also with respect to the duration of maintenance, but, for the most part, pigeons exposed to the negative contingency appear to eventually come to make some response other than keypecking in the presence of the lighted key. This alternative behavior seems to be acquired somewhere in the course of about ten days to two weeks. When it became clear from the initial group data that responding was consistently greater the smaller the trial/cycle ratio, it seemed reasonable to attempt to manipulate responding for individual subjects. Birds which were rapidly ceasing to peck the key were moved to a smaller trial/cycle ratio (in the hopes of more strongly educing the peck before the alternative behavior became strongly established), and the few birds which were still responding on a fairly high percentage of the trials (A3, G2, E1) were moved to a larger trial/cycle ratio. Birds which had been begun on high ratios, and which had consequently never begun to keypeck, were moved to very small ratios in an attempt to initiate responding.

Although all 36 subjects were exposed to this attempt to manipulate responding, only 10 birds were successfully influenced. Three birds begun on initial high ratios were induced to respond (C-3, D-1, D-3). Three high responding birds (A-3, E-1, G-2) were first exposed to high ratios and then to further reversals. Four other birds (B-1, B-2, B-4, F-4) begun on low ratios in which responding had begun to wane were induced to increase responding by moving them to a still lower ratio. Some birds which had ceased to respond were never induced to respond again, even though they had once responded on a large number of the daily trials. These birds seemed as unresponsive to the manipulations as did the birds which were begun on high ratios and which had therefore never made a response: these birds never were induced to respond by manipulating ratios.

Both failure to induce pecking in birds begun on the high-ratio conditions (which had therefore never begun to peck) and failure to reinstate pecking in low-ratio birds (which had once pecked but then quit pecking the key) are of interest, and will be considered in the discussion section of this paper. Of immediate concern, however, are the effects of the ratio manipulations in the birds which did show sensitivity to this procedure. Of these ten birds, eight showed changes in responding with respect to the different ratios which paralleled those effects demonstrated by the group data: the larger the trial/cycle ratio, the smaller was the probability of a response to the lighted key. The other two birds were sensitive over some ratio values, but also showed a strong influence by the opportunity factor: the longer the trial stimulus was available (as in the higher ratio conditions), the more responding was observed.

Referring back to Table 2, it can be seen that each bird was exposed to five or six reversals, with a reversal defined as any change from a high ratio to a lower one, or vice versa. Exposure to each condition (excluding the initial one) usually consisted of 3-11 sessions on that ratio. Overall cycle values for each bird were held constant at the initial cycle value. The last three days of each condition were chosen as comparison sessions. Figure 29 shows the percentage of trials with a response over the last three days of each condition, plotted as a function of successive ratio value for each bird. These data are presented in such a sequential fashion, as it can clearly be seen that there are order effects, that is, the amount of responding correlated with either an increase or decrease in ratio is partially dependent upon how much

Figure 29. Percent trials with a response over the last three days of each condition, plotted for ten subjects across five or six successive trial/cycle ratios within the context of a constant overall cycle duration.


% TRIALS WITH A RESPONSE OVER LAST 3 DAYS ON CONDITION
TRIAL/CYCLE
E-1
10
20
30
40
.20 .80 1.0 .10 1.0
D-3
2
4
6
8
1.0 .20 .10 1.0 .10 1.0
C-3
5
10
15
20
25
.80 .10 1.0 .20 .10 .20 .80
A-3
5
10
15
20
25
.20 1.0 .10 .20 .80 .20
B-1
30
60
90
.40 1.0 .40 1.0 .10
B-2
30
60
90
.40 .10 .40 1.0 .10
G-2
10
20
30
40
.20 1.0 .10 .80 .20
F-4
30
60
90
.40 .10 .80 1.0 .10
B-4
10
20
30
40
50
.40 .10 1.0 .20 .40
D-1
20
40
60
80
1.0 .20 .10 .80 1.0

responding was maintained on the immediately preceding condition. Looking closely at the data for subject E-1, as an example of a bird which was influenced by the manipulations as would be predicted by the group data, it can be seen that responding for this bird was systematically influenced by the ratio value. Upon moving from an initial 20% condition to an 80% condition, percent trials with a response dropped from about 30% of the daily trials to about 13%. When moved to an even higher ratio, 100%, responding dropped even further, to less than 5% of the daily trials. When this bird was then moved to a trial/cycle ratio of 10%, responding quickly increased to a level even greater than it had been on the initial 20% ratio condition. When moved back to 100% again, as in the final condition, responding again dropped to a low of about 6% of the daily trials.

In other birds, the order effects show up more clearly. For subject D-3, for example, the 100% condition occasioned no responding, but neither did the first move to the 20% ratio. The ratio was decreased all the way to 10% before any responding was observed. Even when responding did occur, it was at a much lower level than that seen for most of the other birds at a 10 or 20% ratio, with peak responding occurring on only 8% of the daily trials. Once responding was initiated, however, the behavior consistently demonstrated sensitivity to the manipulation of ratios quite well. The 100% condition occasioned almost no responding, but the subsequent return to the 10% condition brought responding almost back to its former level.

For one bird, A-3, the 10% condition was not effective in educing responding. The bird was otherwise clearly sensitive to the ratio changes, as can be seen by the rise and fall of percent trials with a response. The overall cycle value for this bird was 30 sec. With a ratio of 10%, that makes the trial stimulus itself only 3 sec in duration. It is possible that this brief stimulus did not allow this particular bird enough time to approach the key and complete a keypeck.

The data for another 30-sec cycle bird (B-2) demonstrates how the sequence can influence amount of responding observed. On the initial 40% ratio condition for this bird, responding was being maintained at about 10% of the daily trials. Subsequent movement to a 10% condition caused a big jump in responding, all the way up to a little over 80% of the trials. Then, upon being placed again on a 40% ratio, the same bird maintained responding on the 40% condition on over 60% of the daily trials, a considerably greater number of trials than were containing responses after ten days on the initial 40% condition, yet clearly fewer trials than on the preceding 10% condition.

As mentioned above, two birds (D-1, B-4) responded in a manner not to be expected on the basis of the group data.

Although the initial attempts to increase responding for these two birds by moving them to low ratios were successful, when they were subsequently moved to high ratios (100% for B-4, 80% for D-1), pecking instead increased. It is possible that the increased opportunity to respond afforded by the longer stimuli offset the effect of the ratio.

As has been seen, however, eight of the ten birds taken through these reversals quite strongly supported what has already been found, from the group data, to be the effect of the ratio between trial stimulus duration and overall cycle duration: the higher the ratio, the less likely is responding to be observed. These birds represented all three cycle values: 30 sec, 60 sec, and 120 sec, as did the group data already presented. Specific details of number of sessions each of these ratios was presented are presented along with other details in Table 2.

It appears, then, from both the group data collected over the first ten days of the initial negative-contingency condition, as well as from individual data obtained from sequential manipulations of trial/cycle ratio, that the effect of ratio size on acquisition and maintenance of the pecking response is a strong one. For three cycle values, pecking was seen earlier and at higher rates the smaller the ratio. When specific ratios were examined across cycle values, it appeared that more responding was observed the smaller the value of the cycle, with ratio held constant. This cycle effect was particularly evident when dependent measures were "weighted" for some sort of "opportunity" factor.

Experiment II

The fixed-trials, positive-autoshaping experiment was run as a replication of what had already been obtained on the negative contingency. Besides demonstrating that the same relationships between trial/cycle ratio and responding also held in this procedure, the fixed-trials positive study allowed additional measures to be computed which were not possible in the negative contingency. One of these measures was "working" rate, which was computed as responses divided by all the trial time after the occurrence of the first response on a trial, with all the trial time for trials on which a response did not occur <u>not</u> included in the computation. The first response on any trial also was not computed in this measure, since that response did not occur during the working time, but merely initiated it. Also computed was an "overall trial rate" measure: total number of responses over the entire session divided by total number of sec of trial time over the entire session.

Presented in Table 8 are some summary measures for the three initial conditions. It should be noted that, because these subjects included non-naive birds, measures such as number of pairings prior to the first response and number of

TABLE 8

Positive Fixed-Trials Autoshaping: Six Dependent Measures Summarized Over Last Ten Days of Initial Condition

	P-2	P-5	P-8	$\bar{X}$
TRIAL/CYCLE	.20	.20	.20	
TRIAL	12	12	12	
CYCLE	60	60	60	
TOT NO. RESP	640	8923	1583	3715
% TRIALS W. RESP	56.2	97.2	88.5	80.63
SUCC. DAY RESP ON ≥ 10% TRIALS	9	10	8	8
MAX RESP ANY SESSION	173	1465	324	654
MEAN WORKING RATE	.2877	1.9447	.3446	.8597
MEAN OVERALL TRIAL RATE	.1067	1.4872	.3273	.6404

TABLE 8 (continued)

	P-1	P-6	C-3	$\overline{X}$
TRIAL/CYCLE	.40	.40	.40	
TRIAL	12	12	12	
CYCLE	30	30	30	
TOT NO. RESP	00	983	504	495.7
% TRIALS W. RESP	00	55.4	51.1	35.5
SUCC. DAY RESP ON ≥ 10% TRIALS	0	8	10	4.8
MAX RESP ANY SESSION	0	225	149	124.7
MEAN WORKING RATE	0	.2529	.1455	.1328
MEAN OVERALL TRIAL RATE	0	.1638	.0840	.0826

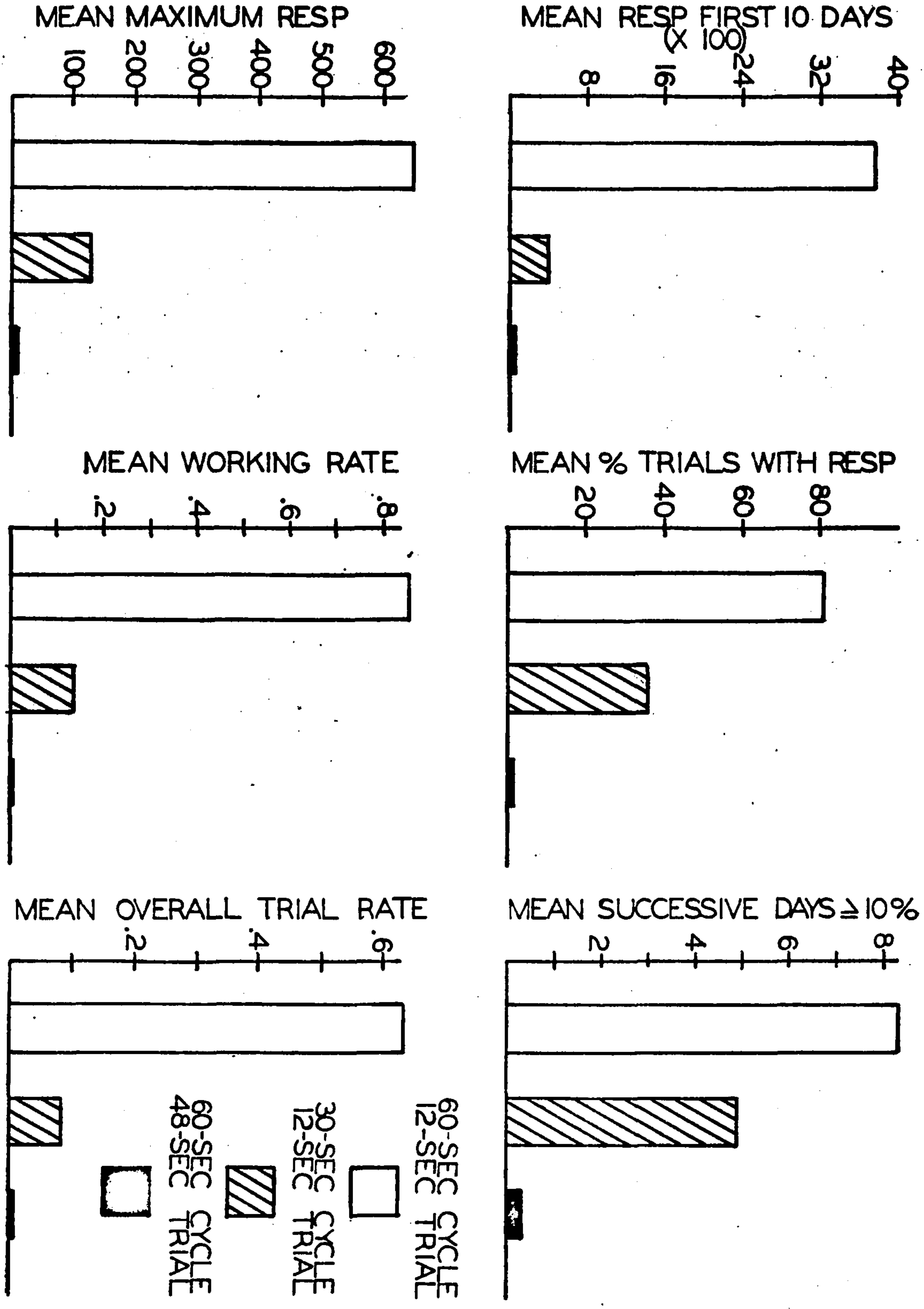
TABLE 8 (continued)

	P-3	P-4	P-7	$\bar{X}$
TRIAL/CYCLE	.80	.80	.80	
TRIAL	48	48	48	
CYCLE	60	60	60	
TOT NO. RESP	8	00	26	11.33
% TRIALS W. RESP	.01	00	.038	.016
SUCC. DAY RESP ON ≧ 10% TRIALS	0	0	1	.33
MAX RESP ANY SESSION	4	0	14	6
MEAN WORKING RATE	.00	.00	.0012	.0007
MEAN OVERALL TRIAL RATE	.0003	.00	.0012	.0005

cumulated sec of trial time prior to the first response are not meaningful here. The three experienced birds are represented among the three initial conditions. Data are again presented from the first ten days of the condition.

The means from Table 8 are presented in Figure 30. Each portion of the figure shows data for the three groups on one of six dependent measures. Note that the absolute trial time for the 60-sec cycle, 20% group and the 30-sec cycle, 40% group is the same: 12 sec. In the upper left-hand portion of the figure, the mean number of responses recorded over the first ten days is plotted as a function of the three groups, with ratio value increasing left to right. While the 20% group made over 3600 responses, on the average, the 40% group with a trial stimulus of the same duration made an average of only around 500 responses. The 80% group, as in the 80% groups run under the negative contingency, responded about 11 times, on the average. It is clear that a cycle value which will occasion a great deal of responding when the trial stimulus is only 20% of the total duration, will <u>not</u> occasion much, if any, responding when the trial stimulus is large relative to that cycle. Likewise, a trial stimulus, such as the 12-sec one shown here for two groups, will not in itself occasion as much responding on a condition in which that trial makes up a large portion of the overall cycle as will that same stimulus if it is only a small portion of the overall cycle.

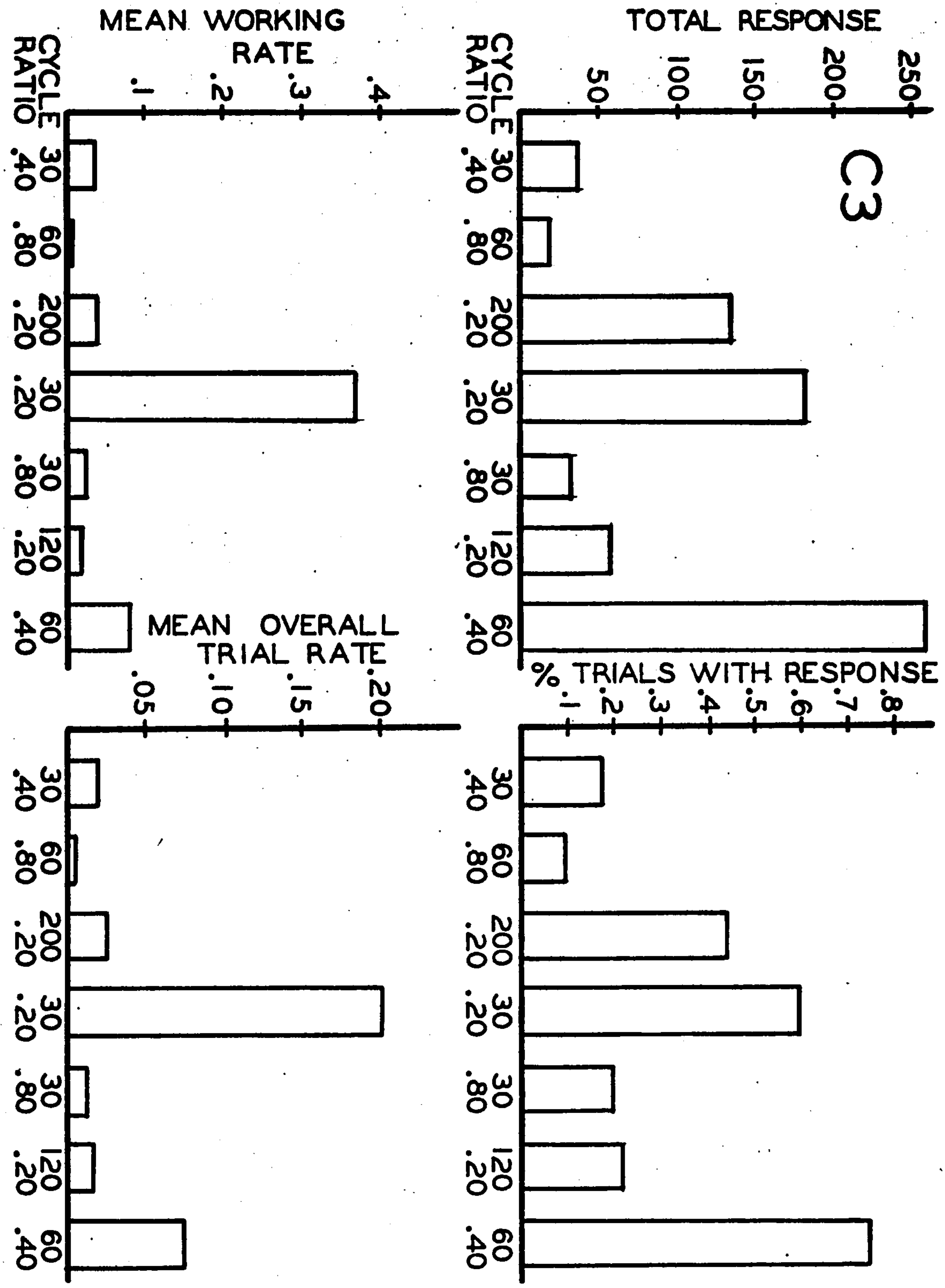
Figure 30. Six summary measures over the first ten days for the group data from the fixed-trials positive autoshaping experiment plotted for each trial/cycle ratio.

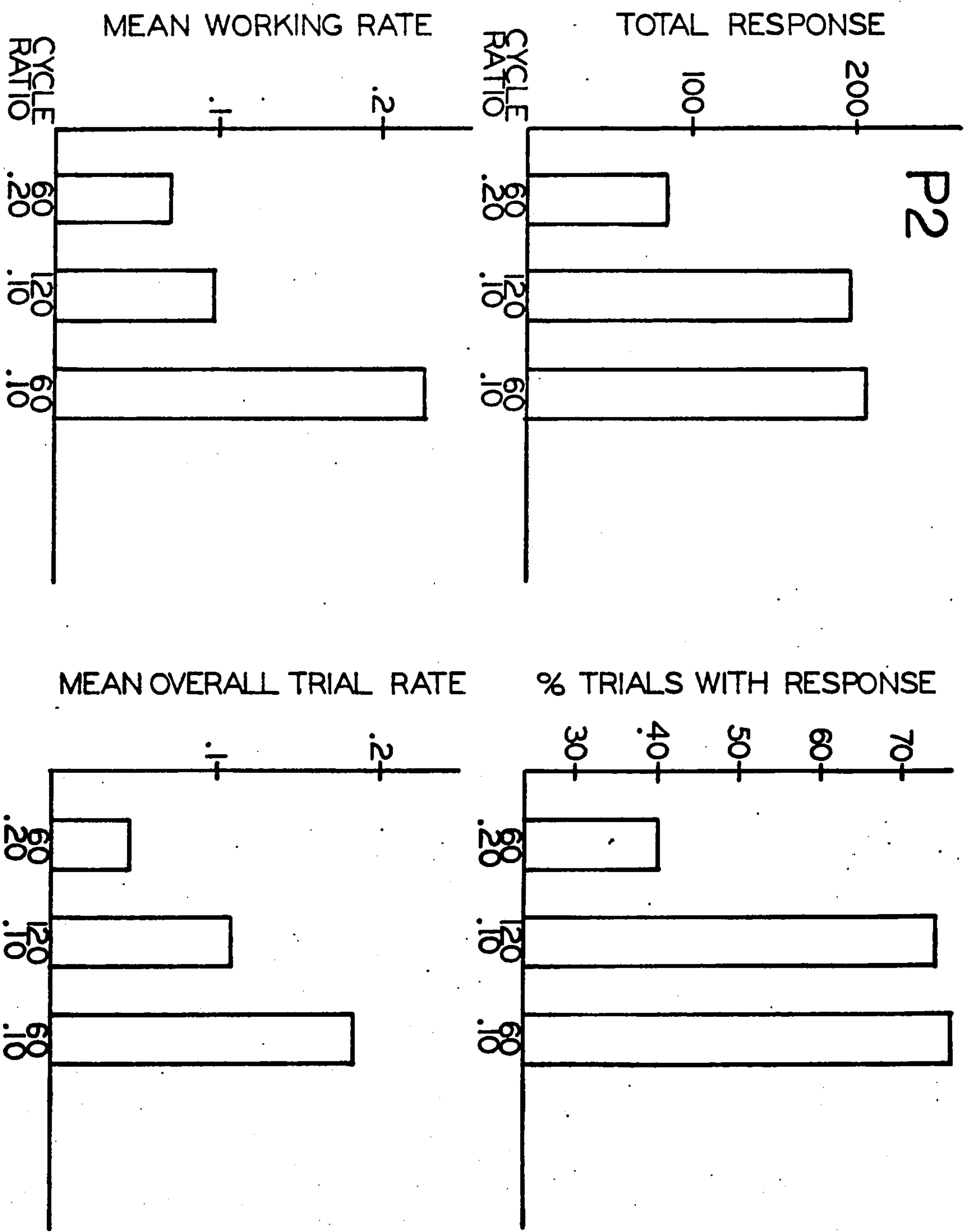

MEAN MAXIMUM RESP
100
200
300
400
500
600
MEAN RESP FIRST 10 DAYS (X 100)
8
16
24
32
40
MEAN WORKING RATE
.2
.4
.6
.8
MEAN % TRIALS WITH RESP
20
40
60
80
MEAN OVERALL TRIAL RATE
.2
.4
.6
MEAN SUCCESSIVE DAYS ≥ 10%
2
4
6
8
60-SEC CYCLE 12-SEC TRIAL
30-SEC CYCLE 12-SEC TRIAL
60-SEC CYCLE 48-SEC TRIAL

Examination of the other five measures presented in this figure supports the same conclusion. Percent trials with a response, successive days with responding maintained on equal to or greater than 10% of the daily trials, maximum responding for any one session, working rate and overall trial rate all show similar relationships among the three groups. The 20% group always shows the highest value, with the 40% group next, and 80% group last, with little or no responding at all.

Individual manipulations: Throughout these two experiments it has been repeatedly demonstrated that the ratio between trial value and overall cycle value is crucial in determining both acquisition (in terms of whether or not acquisition will occur, and, if so, how rapidly) and maintenance level of the keypecking response in the pigeon. The initial data from the negative contingency experiment also suggested that the duration of the overall cycle value is important, in that the amount of responding occasioned by a 20% stimulus will be greater the shorter the overall cycle value. This relationship was somewhat discernible before any attempts to correct the raw number of responses by an "opportunity" factor, and very clear in the corrected figures. Because "rate," which takes time or opportunity into account, is clearly an appropriate measure in a fixed-trials condition, the birds from the initial positive group comparisons were taken through several conditions to determine if there was, in addition to the ratio effect, a cycle value effect within any one subject's data. Because responding in this portion of the experiment was not subject to a negative contingency, it was hoped that high enough response rates would be obtained for easy comparisons across conditions. For a detail of the various conditions to which individual birds were exposed, as well as the number of sessions for each condition, and summary data for several dependent measures, refer back to Table 4.

Figures 31-35 show four dependent measures plotted for each of the five birds which were exposed to the successive manipulations. Four birds which showed no responding to the initial condition were not influenced by either ratio or cycle manipulations. In each figure, the total number of responses, percent trials with a response, mean working rate and mean overall trial rate are plotted as a function of a specific cycle and ratio value. Looking at Figure 31, which shows the data for Pigeon C-3, the effects of the procedure can be examined in detail. In the upper right-hand portion of the figure are plotted the percentage of trials on which a response occurred for the last three days of each condition. Beginning with the initial exposure to the 30-sec cycle, 40% ratio, it can be seen that responding was maintained on about 16% of the daily trials. Changing the condition to a 60-sec cycle, Figures 31-35. Four dependent measures plotted for each of the five subjects exposed to successive manipulations (C-3, P-2, P-6, P-5, and P-8).

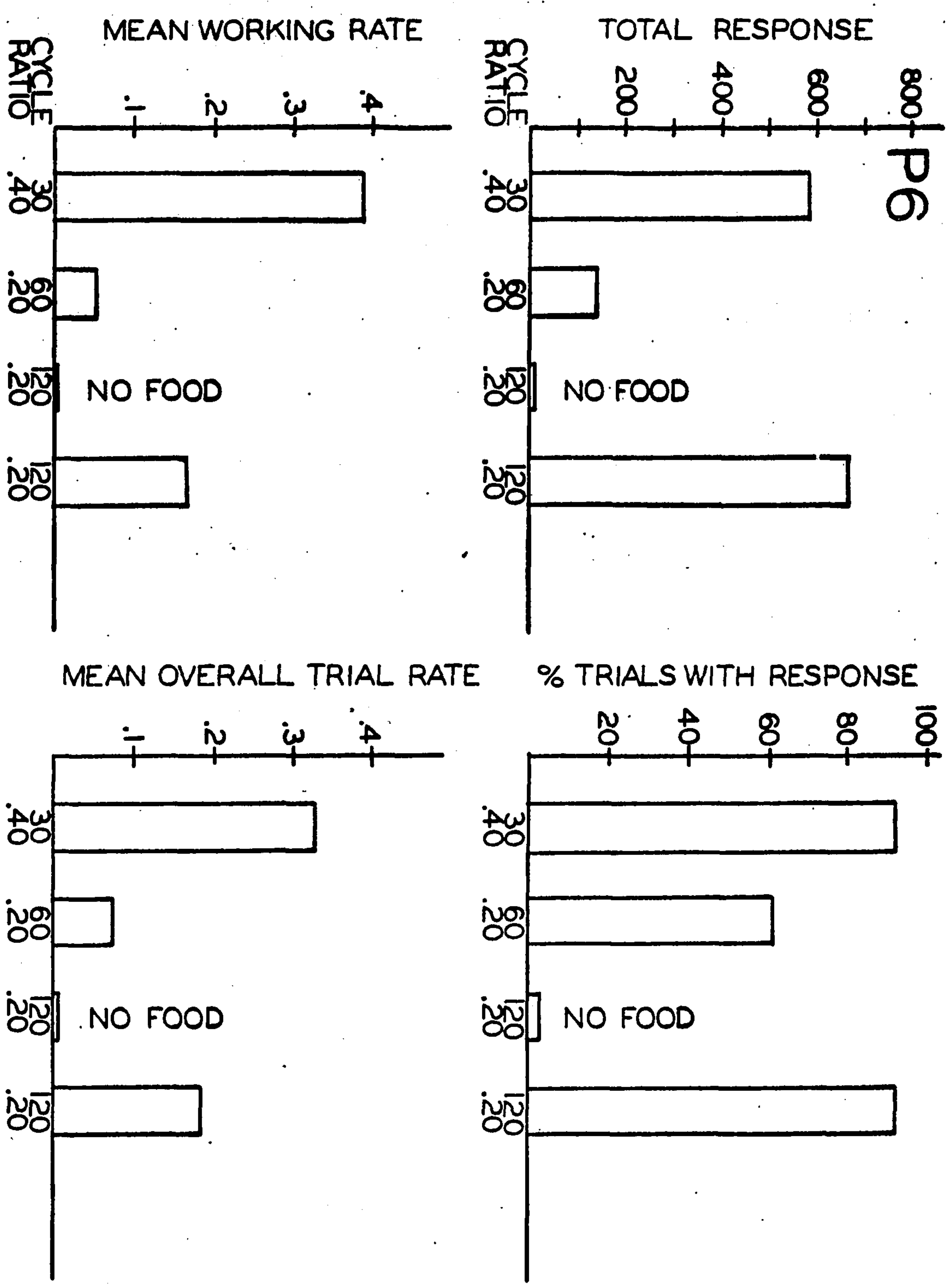

C3
TOTAL RESPONSE
50
100
150
200
250
CYCLE RATIO
30 .40
60 .80
200 .20
30 .20
30 .80
120 .20
60 .40
% TRIALS WITH RESPONSE
.1
.2
.3
.4
.5
.6
.7
.8
MEAN WORKING RATE
.1
.2
.3
.4
MEAN OVERALL TRIAL RATE
.05
.10
.15
.20

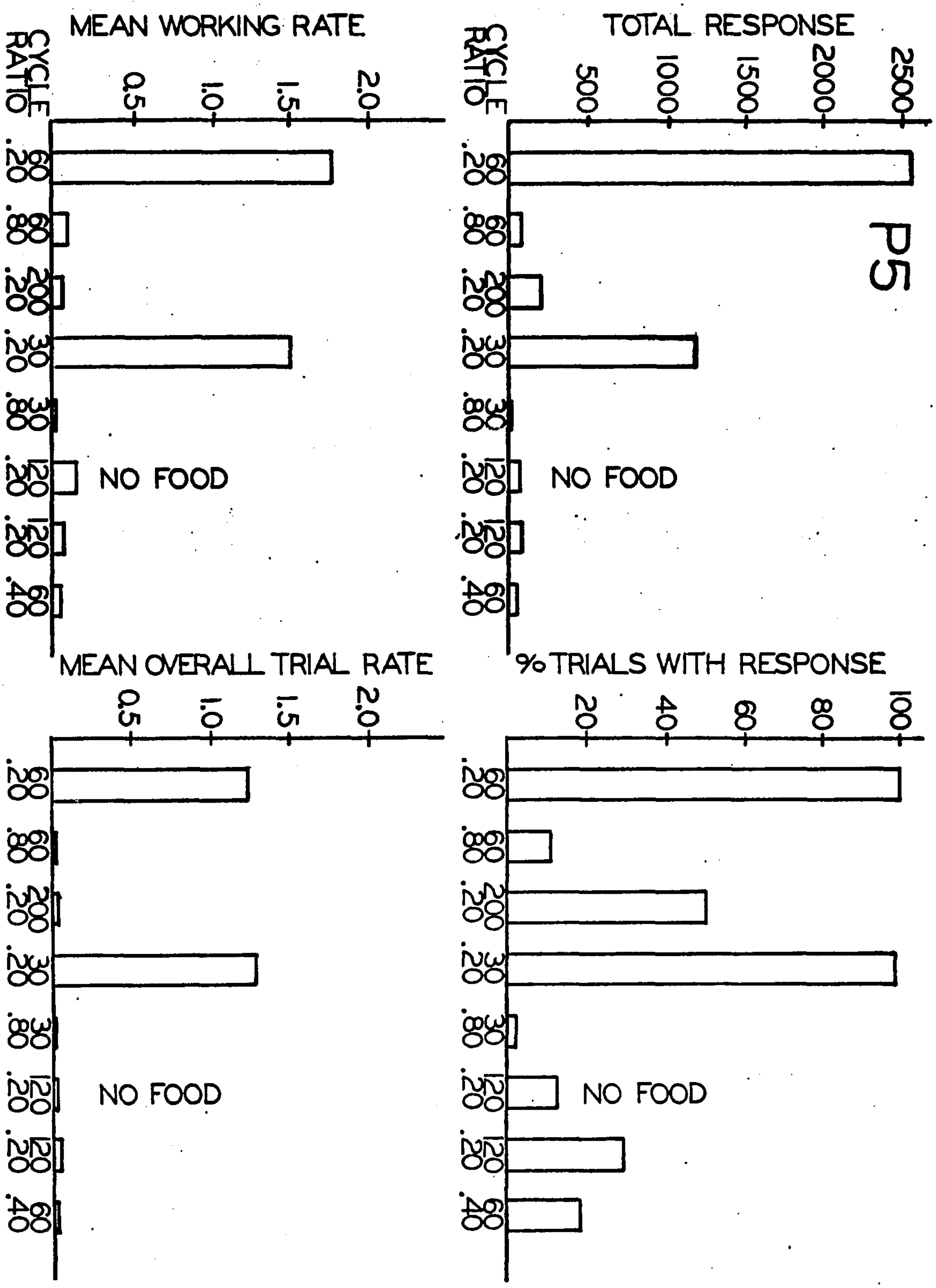

MEAN WORKING RATE

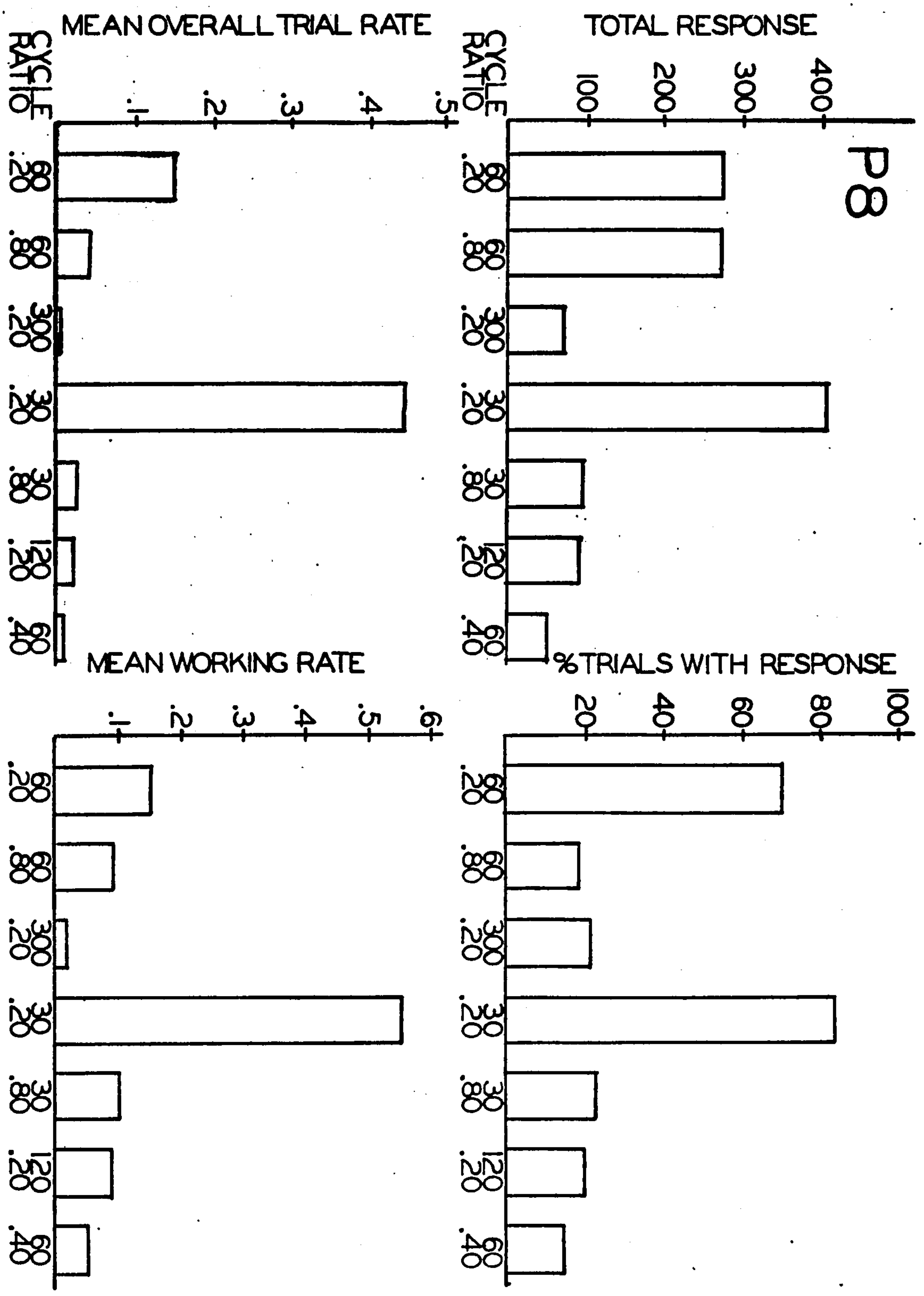
TOTAL RESPONSE

MEAN OVERALL TRIAL RATE

% TRIALS WITH RESPONSE


P6
MEAN WORKING RATE
TOTAL RESPONSE
MEAN OVERALL TRIAL RATE
% TRIALS WITH RESPONSE
CYCLE
RATIO
.1
.2
.3
.4
200
400
600
800
20
40
60
80
100
30
.40
60
.20
120
.20
NO FOOD
120
.20


P5
TOTAL RESPONSE
2500
2000
1500
1000
500
MEAN WORKING RATE
2.0
1.5
1.0
0.5
CYCLE
RATIO
60 .20
60 .80
200 .20
30 .20
30 .80
120 .20
120 .20
60 .40
NO FOOD
NO FOOD
% TRIALS WITH RESPONSE
100
80
60
40
20
MEAN OVERALL TRIAL RATE
2.0
1.5
1.0
0.5
NO FOOD
NO FOOD


P8
TOTAL RESPONSE
100
200
300
400
CYCLE RATIO
60 .20
60 .80
300 .20
30 .20
30 .80
120 .20
60 .40
MEAN OVERALL TRIAL RATE
.1
.2
.3
.4
.5
%TRIALS WITH RESPONSE
20
40
60
80
100
MEAN WORKING RATE
.1
.2
.3
.4
.5
.6

80% ratio caused a drop to somewhere around 8% of the daily trials, half of the number from the previous condition. The trial stimulus duration in the second condition was 48 sec as compared to a stimulus of only 12 sec in the initial condition, so the drop in percent trials with a response cannot be attributed to a decreased opportunity. The ratio of trial/cycle increased, a change which has been repeatedly demonstrated to have the effect of decreasing responding. In addition, the longer cycle also should have had some detrimental effect on responding. Moving next to a 200-sec cycle with a 20% trial/cycle ratio, quite a sharp increase in responding is seen. From what has already been suggested, one would guess that this increase is mainly attributable to the sharp decrease in ratio size, but that, additionally, the lengthening of the cycle size might have attenuated the effect on responding. The absolute trial-stimulus duration itself remained fairly constant (48 sec to 40 sec) in the change from 60-sec (80%) to 200 sec (20%) condition.

If the bird is now moved to a condition in which the all-important ratio size is kept constant but the cycle size is greatly decreased, one should expect an increase in responding if the cycle size is indeed important. When the bird is moved from the 200-sec cycle, 20% ratio to a 30-sec cycle, 20% ratio, this is exactly what happens.

A move back to a higher ratio with the cycle constant again shows the ratio effect. Next, keeping the trial stimulus constant, the bird was exposed to a 120-sec cycle, 20% ratio, and percent trials with a response increased only slightly. Knowing from previous data that the move from an 80% to a 20% ratio should have greatly increased the number of trials with a response, the less than to-be-expected increase might be attributed to the fact that the new cycle value (120 sec) was so long that it attenuated the effect of the optimal 20% ratio. The result of the next move can also be attributed to cycle size, since the ratio increased and the trial value stayed the same, but responding nevertheless increased. In other words, the positive effect of the decrease in cycle size may have offset the negative effect of an increase in ratio.

The three measures represented in the other portions of the figure reflect similar results. Total number of responses over the last three days shows almost identical relationships. Mean working rate and overall trial rate show a sharper difference between the 20% ratios at the 200-sec cycle and 30-sec cycle, but otherwise the relationships are pretty much the same. Note particularly, in the portion of the figure showing working rate, that the change from a 30-sec cycle, 20% ratio to a 30-sec cycle, 80% ratio effects a sharp decrease in rate of responding once responding has begun. Also, the sharp increase from 200-sec cycle, 20% to a 30-sec cycle, 20% ratio shows the cycle effect very clearly.

The data for Pigeon P-2, shown in Figure 32, also give a clear picture of the ratio and cycle effects. In the move from 60-sec cycle, 20% ratio to 120-sec cycle, 10% ratio (notice that the trial value itself remains constant at 12 sec), the data for all four measures reflect an increase. When the bird is then moved from 120-sec, 10% to 60-sec, 10% responding again makes a big jump, particularly in the measures for working rate, a good example of a cycle effect.

When Pigeon C-3 (Figure 31) was moved from the 60-sec, 80% condition to the 200-sec, 20% condition, an increased amount of responding was noted on all measures, in spite of the fact that the trial stimulus stayed near the original value. To make sure that responding observed under this condition was a function of the ratio, and not merely the result of grain being presented with long intervals of non-availability of reinforcement, two birds (P-6, P-5) were run in a 120-sec, 20% condition in which there was no grain hopper present. Trials were the same as in any other condition but instead of a hopper coming up for four sec, the chamber was merely darkened for four sec. It can be seen in Figure 33 (P-6) that such a condition does not sustain responding. Slightly more responding was observed on this condition for P-5, seen in Figure 34.

The data from the fixed-positive autoshaping, then, generally confirm what has already been shown by the negative/contingency study. The initial conditions rendered group data which clearly demonstrated the effect of the trial/cycle ratio. The 60-sec, 20% group showed higher values on all dependent measures than the 30-sec cycle, 40% group, which in turn showed higher values than the 60-sec, 80% group. Individual manipulations for the most part confirmed the ratio effect. Specific cases such as comparisons of 200-sec cycle, 20% and 30-sec cycle, 20% gave strong support on all measures for an effect by the overall cycle value.

DISCUSSION

There were four possible outcomes to the present experiment. Responding could have been demonstrated to be a function of the trial value alone, the cycle value alone, of neither of the two values, or of both the trial and cycle value. The data quite clearly supported the fourth possibility. Throughout the experiment, the _interaction_ of cycle value with trial value has been emphasized. "Ratio" of trial to cycle is, as has been pointed out earlier, only one way of conceptualizing the form of this interaction. A simple ratio of trial to cycle allows one a good prediction of whether or not responding will occur at all, but it has also been demonstrated that knowledge of the absolute values of trial and cycle allows for even better prediction. Further research should be better able to specify the exact function of trial and cycle that determines absolute responding. For the present, we can examine some mechanisms which might be relevant to the data obtained thus far.

Ratio as a Parameter of the Contextual Stimulus

A ratio formulation is convenient not only because it accurately predicts the present results, but also because it fits well into current reconceptualizations of the nature and role of reinforcement. In the negative-contingency study, a general rule could be stated: as the ratio of trial to cycle decreases, the probability of a response increases, whether the trial stimulus itself or the overall cycle be held constant. The best prediction of responding, then, requires a knowledge of both parameters.

There are reasons to expect some aspect similar to ratio of trial to cycle to influence responding in the autoshaping paradigm. In Rescorla's (1967) presentation of a "contingency" viewpoint of the processes involved in associative or classical conditioning, he emphasized the role of the conditioned stimulus (CS) as a predictor of the forthcoming unconditioned stimulus (UCS). He pointed out that the CS need not predict perfectly the UCS, but that it was sufficient that the CS merely be a better predictor than the non-CS periods. This type of analysis has already proved fruitful in the autoshaping experiment, too, as Gamzu and Williams (1971) demonstrated that the keylight did not have to be always followed by food in order for pecking to be established, but that it merely had to accompany a condition in which reinforcement was more likely than it was in the absence of the keylight. The trial stimulus might similarly vary in predictability as the ratio of the trial to cycle varies. A trial stimulus that is lighted for a large portion of the cycle still predicts grain, but other aspects of the experimental environment predict almost as well, and any aspect of the environment predicts as well as a stimulus which is in effect 100% of the time.

An effect similar to the present one has already been noted, in the introduction to this paper. Jenkins (1970), in examining the amount of responding obtained to various groupings of reinforced and non-reinforced trials within a discrete-trials paradign, found that responding to a non-reinforced trial which closely preceded a reinforced trial, was more probable if that non-reinforced trial consistently (predictably)preceded the reinforced trial, and if there was some interval between the two trials and the preceding pair. Control experiments ruled out the possibility that the effect was due to some of the more basic behavioral processes (delay of reinforcement, temporal generalization, etc.). Jenkins discussed these results in terms of a function of the non-reinforced trial as an "especially strong anticipatory signal" (p. 90), and pointed out that such a stimulus could be "expected to generate an especially high degree of excitement," the conditioning of which would be determined by "classical" pairing of the non-reinforced trial stimulus with forthcoming reinforcement.

The "relative proximity" referred to by Jenkins (above), however, differs slightly from the ratio effect which has been pointed out in the present data. In Jenkins' study, the non-reinforced trial was viewed as serving as an anticipatory stimulus for the forthcoming opportunity to earn reinforcement in an "operant" sense. In the present study, of course, the trial stimulus can be viewed as a signal for the delivery of grain, not the delivery of a reinforcer contingent upon operant responding.

The present data, from which we have extracted the "ratio-like" effect, also are compatible with the "generative" and "selective" processes discussed by Staddon and Simmelhag (1971), who offered some reformulations of the current conceptualizations of reinforcement. For example, their repetition of the "superstition" experiment showed that certain behavioral effects are derived from merely periodically delivering certain stimuli (such as grain to a hungry pigeon) into some circumscribed environment. Behaviors which increased in probability as the time for food approached were, in their study as in the present one, food-related behaviors such as pecking. Once these kinds of behaviors are of great enough probability to occur on some regular basis, other effects of the stimulus can assume importance. That is, the behavior might be expected to further increase in probability if it were consistently followed by the food stimulus, or if the stimulus were even made contingent on the occurrence of that behavior. In the autoshaping studies, of course, the differences in responding in the negative versus the positive designs could be attributed to the effects of these other functions of the "reinforcing" stimuli.

These results also seem to bear directly on the manner in which experiments are conducted in the context of classical conditioning. While the CS-UCS interval is commonly varied, the role of the inter-test interval has been obscured, probably due to the discrete-trials nature of the experimental design. From the present data one might very reasonably conclude that the inter-test interval, that is, the actual time between presentations of the CS-UCS pairings, would influence responding not only by means of a ratio effect (how predictive is the CS of the UCS relative to other predictors of the UCS) but also in the nature of the effect of the absolute duration between presentations.

Adjustments for Opportunity and What They Reveal

The ratio effect is very clear. Are there any other consistencies not attributable to the ratio effect which can be seen from these original group data from the negative contingency? If any given ratio value is examined across cycle values, there seems to be something else needed to account for all the data. It was seen that, as cycle size *increased*, the 40% ratio groups (for example) occasioned a decreasing amount of responding. The 40% ratio supported more responding, for most measures, at the 30-sec cycle than it did at the 60-sec cycle, which was in turn more effective than the 40% ratio at the 120-sec cycle. This same type of relationship was also discernible, although not quite as clearly, for the 20% ratios. The values for the 80% ratios were quite low, and this type of comparison was difficult.

We will return to these data in a moment; let us first discuss some of the correction factors which were offered in the results section of this paper. We are concerned here, of course, with extracting data which tell us something about the behavioral processes involved in generating the differential responding which has been obtained in these experiments. It is possible that some aspects of the design might contribute in a way which is essentially trivial. Such a possibility is not immediately obvious for the ratio effect, nor for the cycle value, but there is a way in which the value of the trial stimulus itself might contribute such a trivial effect. If we consider the ratio of trial to cycle to function to build up some tendency to respond, and the probability of a response at any given second (for example) to be a decreasing function of the size of the ratio, then the trial-stimulus duration effects a differential opportunity for that momentary probability to be expressed. In illustration, let the probability of a response at a 20% ratio equal .60, and the probability of a response at a 80% ratio equal .40, at the beginning of each sec. If the 20% ratio is represented by a 6-sec trial stimulus, then the probability of a response will occur in 6 sec ($1 - .40^6 = 1 - .0041 = .9959$). If the 80% ratio, on the other hand, is represented by a 12-sec stimulus, then the probability of a response for any one trial is 1 minus the probability that no response will occur in 12 secs ($1 - .60^{12} = 1 - .0022 = .9978$). These sample values are small in absolute difference, but actually the durations of the higher ratio stimuli were as long as 96 sec. In this example, the probability for any one trial that a response would occur is higher, then, for the 80% ratio group, even though the 20% group functions to produce a much greater tendency to response at any one moment.

Some possible corrections have been offered which might attenuate this biasing factor. Once such correction called for "weighting" the raw number of responses for each group by the total theoretical availability of the trial stimulus; in other words, to weight by the absolute value of the trial stimulus designated for each group. If there is indeed some differential tendency to respond this seems to be an appropriate correction procedure. If, however, all groups are responding on either none or very few of the trials, or if all groups are responding on all of the trials, this weighting method probably is an over-correction.

Differential weighted values could be obtained for the various groups even if the raw number of responses were very similar for all groups.

Given that there are different probabilities to respond occasioned by different ratios, however, <u>some</u> sort of weighting seems necessary in such a negative-contingency design, since only one response can be made per trial. In the sense that the above correction is probably an over-correction at extremes of responding, another possible weighting method was considered: weighting the raw number of responses by the total <u>actual</u> (as opposed to theoretical) trial time, that is, to count only the trial time when the key was actually lighted, and to subtract all of the trial time which was canceled by the occurrence of a trial response. This weighting procedure is superior at the upper end of responding to the first proposed. If a bird is responding on most or even all of the trials, the trial time still could reflect a differential probability of responding, in that longer latencies would indicate lower probability even if percent of trials with a response did not reflect that difference. On the other hand, when birds are responding on some very low number of trials, which was unfortunately sometimes the case in the present experiment, this correction by actual opportunity might have the same criticism directed towards it as does the correction by theoretical opportunity. When there is little or no tendency to peck the key, either kind of correction factor overcorrects for the birds on the long stimulus conditions.

To the extent that these corrections are acceptable, what do they show? In addition to the ratio effect, another effect is seen very clearly: as cycle size decreases, more responding is obtained for any particular ratio value. By implication this statement also says that as trial size decreases, more responding is seen for any given ratio value, since we have seen that trial and cycle size will vary together with ratio value being held constant. It should be remembered that, before any corrections were made, this effect was discernible for some groups (particularly the 40% groups).

In the fixed-trials positive experiment, the ratio effect was also seen very clearly. In the initial group study, when cycle was held constant and trial stimulus (and therefore trial/cycle ratio) varied, the raw number of responses, percent trials with a response, working rate, and overall trial rate were all decreasing functions of the ratio of trial/cycle. Additionally, when the trial-stimulus duration was held constant and the cycle value varied (and therefore the ratio value varied), these measures were again a decreasing function of the trial/cycle ratio.

In the positive procedure, the trial stimulus remains on for the duration of the trial irrespective of responding. Differential tendencies to respond induced by the ratio effect, then, can be reflected appropriately as _rate_ measures. Overall trial rate roughly corresponds to the data corrections by theoretical opportunity for the negative contingency, while working rate corresponds to the actual opportunity corrections. When opportunity for a response is continuously available, as in a fixed-trials procedure, then the probability of a response can express itself over some real time. In the individual manipulations for these positive-trial birds, we were able to see, on measures such as raw number of responses, percent trials with a response, working rate, and overall trial rate, _increases_ when subjects were moved from long cycle (and long stimulus) conditions to short cycle (and short stimulus) conditions even though ratio, the major determinant of responding, was being held constant. Decreases, on the other hand, were seen in these dependent measures when the move was in the opposite direction. These data are taken to support those from the negative contingency which indicated that the absolute values of the cycle (or trial) were important as well as their values _relative_ to each other.

The Importance of Absolute Values

There are two effects to account for, then, the ratio effect and the effect of the absolute size of the cycle (or alternatively, the trial stimulus). Through the results section, we have referred primarily to the latter effect as an effect of cycle size, rather than as an effect of the absolute trial-stimulus duration. Because these two parameters of necessity vary together, this partiality in expression cannot really be supported. Changes across groups which have been attributed to cycle might just as well have been attributed to trial. Let us assume that the ratio value is still a major feature of the experimental context, in that the trial stimulus must be small enough relative to the overall cycle to be of value as a predictor not only of whether or not grain will occur, but also a predictor of how imminent that grain delivery is. But imagine two extreme situations. In the first, assume that the trial/cycle ratio is within the range of values which have been found to be effective in educing the most responding. The cycle value, however, if very short, may occasion grain so frequently that the role of the trial as a signal is irrelevant. In other words, if grain comes too frequently, the bird's attention and activity might be predominantly directed at the hopper and grain itself, in such a way that key-directed behaviors would be precluded. This situation, however, would not be as likely as the other extreme, in which grain would come so rarely that little anticipation of the grain would direct responding toward the key. If, for example, grain were delivered only once every three or four hours, it might be a relatively unimportant event, in that it occurred too infrequently to have much regular influence upon the behavior of the organism. It seems reasonable, then, to expect that the effectiveness of the cue (trial stimulus) depends not only upon how much information it carries, but also on how relevant that information is to the state of the organism. If the intervals between deliveries of reinforcement are too vast, that "expectation" of food might be so low that cues were irrelevant. Premack and Bahwell (1959) found operant level of lever-pressing in a monkey to be an increasing function of duration of inter-test interval. On the other hand, if food is presented extremely rapidly, ratio value associative cues might be irrelevant in the sense that there is continual anticipation of food.

There are also reasons, perhaps, to expect the absolute value of the trial stimulus to be relevant, and, at present, final decisions about which is causing the effect seen in the present data certainly cannot be offered. As mentioned above, however, it might be expected that the duration of the trial stimulus would show an opposite effect from that which has been seen here, in that the longer stimuli afford more opportunity for a keypeck to be made than do the shorter stimuli. This factor, although quite probably in operation, seemed by no means to overshadow the opposite effect; that is, the trial should be short relative to the overall cycle in order for optimal responding to be observed. In what ways might the absolute value of a stimulus produce the obtained effects? It is true that the shorter stimulus has the delivery of grain more closely associated with its onset than do the longer stimuli, but it is the offset of the trial light which is consistently paired with reinforcement. And if it be suggested that it is some brief period immediately prior to reinforcement in which responding should be obtained, as would be predicted from Pavlovian delay conditioning, it can be argued that the longer trial stimuli contain within themselves these shorter trial stimuli. Under the longer trial-stimulus condition, responding could very well have been limited to some discrete portion of the longer stimulus.

There is one role of the trial stimulus which must be ruled out in order to maintain the argument that it is the trial/cycle ratio which is the main determinant of responding. A case might be made for the trial duration functioning to produce reinforcement at different delays under the different trial-stimulus conditions. It might be argued, for example, that if responding occurs early in the trial stimulus, that responding is reinforced with a delay which depends upon the value of the trial stimulus. Responding to the short trial stimuli, under the positive fixed-trials conditions, is followed by reinforcement either immediately or with a very short delay. This is in reference to "adventitious" reinforcement, of course, since there is no contingency in the positive condition. This argument could not be used under the negative-contingency design, since responding can never be followed at any delay (except from one trial to the next) by reinforcement when a negative response contingency is imposed. Under the positive procedures, however, responses reinforced with a longer delay would be considered to undergo less strengthening than those reinforced with no delay or with short delays. This differential strengthening could be used to explain the differential responding to the trial stimuli, an effect which in this paper has been primarily attributed to the effect of the trial/cycle ratio.

There is, of course, a very good reason to rule out such a contention. Absolute trial values of constant duration were compared, both in group and individual conditions, when the ratio value itself was manipulated. In the initial group conditions under the fixed-positive trials, for example, the 60-sec, 20% group and the 30-sec, 40% group were exposed to trial stimuli of equal absolute duration (12 sec). If the delay of adventitious reinforcement produced differences in amount of responding, then there should have been no differences for these groups, and we have seen that there were very large differences. The

20% group exceeded the 40% group on nearly all measures of maintenance.

The differences in the groups in both the negative contingency and the positive-trials conditions might also be attributed to the differences in the delay of the UCS (grain), under a classical conditioning model. In this case, differences in responding would not be attributed to the consequences of responding, but rather to the fact that behavior was elicited with more or less strength according to the delay between the onset of the CS (trial light) and the presentation of the UCS (grain). In Pavlovian conditioning, in fact, the CR will not even be obtained (at least initially) if the interval between CS and UCS is too long (Pavlov, 1927, pp. 88-89). This is a particular criticism which might be leveled at the correction factor computed for the responding under the negative contingency. If the tendency to respond will be later in the interval the longer the delay between the CS and UCS, then weighting by opportunity would unfairly bring disadvantage to the birds in the long trial stimulus groups (and consequently those with high trial/cycle ratios). We have already seen, however, that the working rates in the fixed-trials positive conditions replicated the negative-contingency data, so results generally do not support such a criticism. Additionally, just as in ruling out delay of adventitious reinforcement, the fact that equal trial-stimulus values yield different amounts of responding according to ratio of the trial to the overall cycle also controls for the delay of reinforcement effect in the classical conditioning context.

It could be suggested that the eductional effect of the keylight and grain pairings does function to produce some tendency to respond, and that this tendency itself is not differentially strong with different ratio values, but that the educed responding, if it occurs relatively close to keylight onset, is just more likely to come in contact with reinforcement in the smaller ratios. In the longer stimulus conditions (and therefore higher ratios) responding could occur early in the trial, but other subsequent behavior could intervene between that pecking and the presentation of reinforcement, such that these other behaviors would be themselves operantly strengthened and interfere with the production of the pecking response. The fact that ratio differences were consistent in the negative contingency as well as in the positive conditions seems to rule out this possibility, since a response in the negative condition can never be followed by reinforcement, in the short stimulus conditions or the long stimulus conditions. In fact, as pointed out in the results section, it was the birds on the small ratio and short stimulus conditions which made the most responses, and consequently which received the fewest reinforcements. Additionally, the comparison of equal trial durations serving as different proportions of the cycle again makes it difficult to see how ratio effects could be attributed to any function of the absolute trial duration.

The Relationship of These Results to Other Autoshaping Data

In the present experiment, relatively little responding was obtained in the negative contingency, so the eduction effect might be viewed as being relatively weak. It is possible that, given a different environmental context, the eduction effect would have been so strong that no differences would have been observed between groups, at least in the negative-contingency condition. If the general procedure quite strongly elicited pecking, there may have been differences in strength as a function of ratio, but the strength on all conditions could have been strong enough to get at least that one keypeck possible on the negative contingency. It has recently been suggested (Wasserman, 1972) that, contrary to what might seem reasonable on first glance, the keylight and non-keylight periods need be minimally discriminable in order for the keylight to maximally educe pecking. On the theory that pecking is most likely to be educed when the pigeon is orienting and attending to the key, Wasserman notes that the key will be most relevant to a bird in a situation in which he cannot discriminate the initiated trial by, for example, changes in the general illumination of the chamber. With a bright houselight and dim keylight and a dim houselight (or no houselight at all) the general illumination of the chamber increases so much when the trial comes on that the bird can discriminate the initiation of the trial even with his "back" to the key.

Intuitively, it might have seemed that the key should "stand out" as much as possible from its surround in order for maximal "attention" to be directed toward it. It was noted in the procedure section of this paper that the keylight was transilluminated with three (rather than the usual <u>one</u>) bulbs, and that the houselight was not only deflected toward the ceiling, but also shielded with brown paper. This was done to make the illumination prior to the onset of the trial light as different as possible from the illumination after the onset of the trial. If Wasserman is correct, and his data are certainly convincing, then the steps taken in this experiment were, of course, not at all appropriate to educe maximal pecking under either the negative or positive conditions.

Initial comparisons in the present study were of the nature of group designs because it had already been seen in this laboratory that pigeons exposed to a negative contingency sometimes transferred the location of their pecking from the key to some idiosyncratic portion within the chamber (often an area adjacent to or surrounding the key). A similar phenomenon was observed in the present research under the negative contingency. Even when birds on initial conditions which proved to be appropriate for the most rapid acquisition of the pecking response (small trial/cycle ratios, particularly those within a relatively short overall cycle) began pecking on some large percentage of the trials, over a period of approximately ten days responding was observed to rapidly decrease. When some of these birds which had ceased to respond were moved to smaller ratios in the hopes of reinstating responding, they could never be returned to the key. Off-key pecking during the trial could be clearly observed in most of these birds. This trial behavior in most cases could be clearly discriminated observationally from intertrial behavior, but such an analysis was not pursued in detail.

In addition to the birds which had once pecked but then ceased pecking the key, there was also a large number of birds (mostly those begun on large ratio values, with a long cycle value) which never in the course of the experiment made more than one or two responses. Two birds begun on 80% and 100% conditions under the 30-sec cycle were induced to respond when their ratios were decreased to 10% or 20%. The fact that it was only the 30-sec cycle birds which overcame the initial effects of the poor ratio condition may have been coincidental, but such a result fits well with the evidence already presented for increasing ratio effectiveness as cycle value decreases.

Gamzu's (1971) explanation as to why non-differential training prior to differential training interfered with acquisition under the differential conditions was one in terms of interference by a competing response. If reinforcement initially occurs in a situation in which responding (keypecking) is not educed, as in his non-differential condition, or as in the high ratio conditions in the present experiments, Gamzu proposed that some other behavior would come in contact with the reinforcing stimulus and therefore be strengthened adventitiously. If, however, the initial reinforcers are present in a context in which responding is educed, as in Gamzu's differential condition, and as in the short ratios in the present experiments, then the educed behavior itself will be followed by reinforcement and a positive feedback loop will be established such that the behavior will be observed with a high rate. In the negative contingency, of course, this feedback loop should be circumvented by the negative response contingency, so responding observed should be attributable to the eduction effect alone. According to such an explanation, the birds in the long ratio conditions in the present study should have demonstrated highly repetitive "superstitious" behavior in the presence of the trial stimulus. Observation of these birds, however, often revealed them to be sitting immobile in front of the hopper, apparently "waiting" for the food to be freely presented.

Some recent evidence which questions the competing response hypothesis offered by Gamzu is that of Engberg, Hansen, Welker, and Thomas (1972). In comparing acquisition of pecking under an autoshaping design for three groups of pigeons (one group was naive, one had received response-contingent reinforcement for treadle-pressing, and one group had received response-independent delivery of reinforcement), acquisition was found to be most rapid for the group which theoretically should have the strongest competing response. The treadle-pressing group, which had not only been reinforced for a response other than key-pecking, but reinforced directly rather than adventitiously, most rapidly began pecking the key when exposed to an autoshaping procedure. Second most responding was seen for the group which was experimentally naive, and the birds which had received response-independent reinforcement showed the least pecking. These experimenters reported their findings in the context of the "learned non-contingency" or learned "helplessness" literature, which suggests that animals exposed to response-independent events (such as the delivery of a painful shock) are inferior to naive controls in acquiring an instrumental response to escape or avoid such a stimulus. In the present context, it was suggested that the birds in the response-independent group pecked less not because some other behavior(s) was reinforced adventitiously, but rather because they had learned that stimulus events impinging upon them were not a function of their own behavior. The superiority for the treadle group appears to be good evidence that such a "learned laziness," as the effect was named by the authors, could rule out a competing-response hypothesis in accounting for order effects.

BIBLIOGRAPHY

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

Brown, P. L., and Jenkins, H. M. Autoshaping of the pigeons's key-peck. *Journal of the Experimental Analysis of Behavior*. 1968, *11*, 1-8.

Engberg, Larry A., Hansen, Gary, Welker, Robert L., and Thomas, David R. Acquisition of key-pecking via autoshaping as a function of prior experience: "Learned laziness"?. *Science*, 1972, *178*, 1002-4.

Gamzu, Elkan. Random reinforcement impairs rates of autoshaped pecking produced by non-paired associative procedures. Paper presented at meeting of the Eastern Psychological Association, New York, April, 1971.

Gamzu, Elkan, and Williams, David R. Classical conditioning of a complex skeletal response. *Science*, 1971, *173*, 923-925.

Gardner, William M. Auto-shaping in bobwhite quail. *Journal of the Experimental Analysis of Behavior*, 1969, *12*, 279-281.

Hendry, Derek P. *Conditioned reinforcement*. Homewood, Illinois: The Dorsey Press, 1969.

Jenkins, H. M. Sequential organization in schedules of reinforcement. In Scoenfeld, W. N. (Ed.), *The theory of reinforcement schedules*. New York: Appleton Century Crofts, 1970.

Morse, W. H., and Skinner, B. F. A second type of superstition in the pigeon. *American Journal of Psychology*, 1957, *70*, 308-311.

Pavlov, I. P. *Conditioned reflexes: an investigation of the physiological activity of the cerebral cortex*. New York: Dover Publications, 1960.

Premack, David, and Bahwell, Richard. Operant-level lever pressing by a monkey as a function of intertest interval. *Journal of the Experimental Analysis of Behavior*, 1959, *2*, 127-131.

Quattlebaum, Lawrence F. Autoshaping of lever-pressing in retardates. Unpublished doctoral dissertation, University of Georgia, 1971.

Rescorla, Robert A. Pavlovian conditioning and its proper control procedures. *Psychological Review*, 1967, *74*, 71-80.

Schwartz, Barry, and Williams, David R. The role of the response reinforcer contingency in negative automaintenance. *Journal of the Experimental Analysis of Behavior*, 1972, *17*, 351-357.

Sheffield, F. D. Relation between classical conditioning and instrumental learning. In W. F. Prokasy (Ed.), *Classical conditioning*. New York: Appleton-Century Crofts, 1965, 302-322.

Sidman, Murray, and Fletcher, G. Garth. A demonstration of autoshaping in monkeys. *Journal of the Experimental Analysis of Behavior*, 1968, *11*, 307-309.

Skinner, B. F. *The behavior of organisms: an experimental analysis*. New York: Appleton-Century crofts, 1938.

Skinner, B. F. Superstition in the pigeon. *Journal of Experimental Psychology*, 1948, *38*, 168-172.

Skinner, B. F. The phylogeny and ontogeny of behavior. *Science*, 1966, *153*, 1205-13.

Smith, Stanley G., Borgen, Lowell A., Davis, W. Martin, and Pace, Henry B. Automatic magazine and bar-press training in the rat. *Journal of the Experimental Analysis of Behavior*, 1971, *78*, 3-43.

Smith, Stanley G., and Smith, William M. A demonstration of autoshaping in dogs. *Psychological Record*, 1971.

Wasserman, Edward A. *Autoshaping: the selection and direction of behavior by predictive stimuli*. (Doctoral dissertation, Indiana University) Ann Arbor, Mich.: University Microfilms, 1972, No. 72-15, 935.

Watson, Douglas P. Autoshaping and maintenance in mentally retarded children. Unpublished master's thesis, Georgia Southern College, 1971.

Williams, David, and Williams, Harriet. Automaintenance in the pigeon: sustained pecking despite contingent non-reward. *Journal of the Experimental Analysis of Behavior*, 1969, *12*, 511-520.