A TEST OF THE AUTOPECKING THEORY OF BEHAVIORAL CONTRAST

by

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Table of Contents

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List of Illustrations

When a discrimination is trained using the method of successive presentations of stimuli, subjects are shown only one of two discriminative stimuli on each trial and reinforcement is typically given only in the presence of one stimulus while it is not with the other. With this procedure the subject learns to respond in the presence of one stimulus (the one associated with reinforcement), and to not respond in the presence of the other stimulus. This may be viewed as a combination of two simple procedures: conditioning and extinction. This fact was used by certain classical theorists (Spence, 1936; 1937; Hull, 1943) to propose an explanation of discrimination learning.

Spence (1937) for example, postulated five basic principles of discrimination learning when the problem involves a stimulus dimension of a continuous nature. (1) As a result of reinforcement, there is an increase in the excitatory tendency to approach the positive (reinforced) stimulus. (2) There is generalization of this acquired excitatory tendency to similar stimulus objects. (3) The lack of reinforcement in the presence of one stimulus results in an increment of the inhibitory tendency to other stimulus objects. (5) The effective excitatory strength of a stimulus is the algebraic summation of these two positive (excitatory) and negative (inhibitory) tendencies. In addition, Spence was forced to assume that the magnitude of the inhibitory gradient is less than that of the excitatory one.

Unless additional principles are invoked, conditioning-extinction theory leads to certain specific predictions, some of which were tested by Gynther (1957). The prediction with which

we will be most concerned involves the level of conditioning to the positive stimulus in a discrimination situation. From the five assumptions one would predict that the generalization of inhibition from the negative stimulus to the positive should theoretically result in a reduction of response strength to the positive stimulus. This effect is known as negative induction. Gynther (1957) using differential eyelid conditioning, found an induction effect, i.e., a greater percentage of CRs were given to CS+ if single stimulus training was used than if discrimination training was given. In addition, Gynther found that if pre-training to CS+ was given prior to discrimination, then there was an initial decrease in response strength to CS+ once discrimination training began. These results are completely in accord with the predictions of conditioning-extinction theory.

Henderson (1966) reported another example of induction using rats in a runway with two discriminative stimuli. In the presence of one stimulus (S1), reinforcement was presented 100% of the time while the other stimulus (S2) had a smaller percentage of trials reinforced. Results show that as the running speed to S2 decreases, there is a corresponding decrease to S1. A similar study was done by MacKinnon (1967) except that magnitude rather than percentage of reward was varied in the presence of S2. The results are similar to Henderson's in that an induction effect was shown. Although these data may be explained in other ways, they are at least compatible with the generalization of inhibition prediction derived from conditioning-extinction theory.

There are, however, a large number of discrimination studies that do not demonstrate generalization of inhibition. Not only is this effect absent in these studies, but a completely opposite reaction tends to appear. In these cases, as the response strength to the negative decreases there is an increase of response strength to the positive stimulus. Following Skinner (1938), we will call this effect positive behavioral contrast. A great deal of evidence has been accumulated to show that contrast is a real effect. The earliest demonstration of it was by Pavlov (1927), who first noticed that if a positive trial immediately followed a negative, there was an increase in response magnitude to the positive. Verplanck (1942), using rats, showed an increase in running speed to S+ when a discrimination is established in a runway. A similar effect on jump-stand latency was reported by Solomon (1943). The vast majority of contrast studies, however, have been conducted with a free operant discrimination in which the subject is free to respond at any rate during the positive and negative stimulus components. In this case, a subject will respond frequently to the positive and greatly decrease responding to the negative. Using rats in such a situation, Smith & Hoy (1954) demonstrated contrast although the overall rate of responding remained constant as the discrimination was formed. The authors stated that this was due to a shift in responding from the negative periods to the positive ones.

The first investigation of contrast using pigeons in a free operant situation was conducted by Reynolds (1961). In this study, Reynolds showed that contrast would occur whenever S+ was

correlated with a variable interval schedule of reinforcement and when S- was a specific stimulus light or simply a time-out, which immediately produced a near zero rate of response. However, contrast did not occur when S2 was correlated with a differential reinforcement of other behavior (DRO) schedule, in which reinforcement is contingent upon not responding. This schedule produced very low response rates, but did maintain a high frequency of food presentation. Based on these data, Reynolds (1961) hypothesized that frequency of reinforcement is the variable that controls the contrast effect. "The frequency of reinforcement in the presence of a given stimulus, relative to the frequency during all of the stimuli that successively control an organism's behavior, in part determines the rate of responding that the given stimulus controls (p. 70)."

After examining these data, other investigators (Amsel, 1971; Terrace, 1966; 1968) arrived at different conclusions about the contrast effect. More specifically, Amsel (1971) believes that if trials follow each other in rapid succession, the frustrative effects of nonreward should operate to increase the level of responding to an immediately succeeding S+ and this accounts for contrast. If, however, the trials are spaced, the temporary, labile effects of frustration should dissipate, leaving the more permanent associative effects of generalized conditioned inhibition. This, in turn, yields a relative reduction in response strength to the succeeding positive stimulus. With this theory, Amsel can account for the results of many of the previously cited studies. For example, Verplank (1942) and Solomon

(1943) demonstrated contrast using a discrete trials procedure and each study used a relatively short intertrial interval. Also, since an operant procedure involves the use of either short or no intervals between stimulus presentation, operant studies are not incompatible. Although Henderson (1966) and MacKinnon (1967) demonstrated induction effects, these studies utilized intertrial intervals in the range of 15-20 minutes which are long enough for the effects of frustration to dissipate. Thus, these studies are all in accord with the predictions of the Amsel (1972) theory. The only results antagonistic to the theory are those of Gynther (1957). However, it should be pointed out that Gynther's is the only classical conditioning study in the group and this fact may have accounted for his results of an induction effect under a short intertrial interval.

The Terrace (1966; 1968) position is similar to that of Amsel (1971) except that response suppression is viewed as the necessary condition for contrast. Specifically, Terrace feels that response suppression results in emotional behavior which is manifested as instrumental responding during the positive component. He agrees with Amsel in proposing that the emotional reaction has its effect on immediately subsequent behavior. At the same time, however, he states that the differential reinforcement procedure is an even more important factor.

As support for this position, Terrace cites evidence that contrast does not occur when a discrimination is learned without errors. He also states that contrast will occur when a mult VI DRL schedule is used even though at least 50% of the reinforcements

are gained during the DRL component. This position has, however, come under attack recently. For example, Sadowsky (1973) demonstrated a contrast effect during an errorless discrimination. Also, Freeman (1971)pointed out that response suppression never occurred during the DRL component of the multiple schedule of Terrace's 1968 study. In that particular study, S2 was always correlated with a DRL and the response rate was never high enough for any suppression to occur. As a result, Freeman (1971) stated that until a method is developed which adequately separates the effects of reinforcemtn frequency and rate of responding, it is impossible to choose between those two interpretations of contrast. Due to these and other criticisms, Terrace (1972) amended his theory to state that active inhibition of responding must occur in order for contrast to develop.

There have, however, been other recent hypotheses concerning contrast. Referring to the paradigm of nondifferential followed by differential training, Premack (1969) suggested that contrast will not occur in the second phase unless S2 is capable of generating inhibition or aversiveness. That is, contrast occurs only if an inhibitory gradient can be obtained along the dimension to which S2 belongs. He states that "contrast results if and only if there is a change in the aversiveness associated with one of the components in the schedule (p. 136)." Premack continues by saying that inhibition and contrast are two sides of the same coin and that the necessary and sufficient conditions for the two phenomena are the same.

Although this interpretation appears to be very similar to Terrace's (1972) latest theory, there are some major differences between them. In the first place, the exact cause of contrast is different in the theories. Terrace implies a chain of events leading to contrast. That is, due to non-reinforcement for responding during S-, emotional responses develop. These emotional responses are then said to be aversive and the animal learns to avoid this by making responses which are antagonistic to the instrumental act. This is seen as an active withholding of responding and is defined as inhibition. Contrast is presumed to be an aftereffect of withholding responses to S-. Thus, Terrace feels that withholding responses is a sufficient condition for the establishment of contrast.

This explanation would appear to be invalidated by the previously mentioned study of Sadowsky (1973). In this study, it was demonstrated that contrast would occur when a time out or black out was used as the negative stimulus, even though the subjects never responded in these conditions.

The Premack (1969) explanation, however, is much more vague than that of Terrace. Although he argues that an increase in aversiveness associated with one component is necessary for both contrast and inhibition, he never specifies the conditions in which there is an increase of aversiveness. In this case, Premack does not really "explain" the contrast effect. He merely invokes a pseudoexplanation which cannot be refuted. For any demonstrations of contrast, he states that there was an increase in aversiveness in the variable component and thus can account for virtually all demonstrations of the effect.

The final hypothesis we will consider here and the one with which this study is concerned was first suggested by Gamzu & Schwartz (1973). This will be referred to as the autopeck explanation of contrast. Very briefly, Gamzu & Schwartz demonstrated that reliable key pecking could be obtained with pigeons using a multiple schedule in which periods of reinforcement presented on a variable time schedule alternated with periods of extinction. A variable time schedule is one in which reinforcements are presented at varying intervals of time on a response independent basis. Gamzu & Schwartz explained this effect by stating that pecking is produced whenever food is delivered to a hungry pigeon. Pecks were directed at the key in this case because the key stimulus was a differential signal for food presentation. That is, a stimulus-reinforcer contingency was established which resulted in pecking behavior.

In the typical operant situation, there is also a response-reinforcer contingency which means that an operant discrimination involves both stimulus-reinforcer and response-reinforcer contingencies. Gamzu & Schwartz believe that a mutually enhancing effect (i.e., contrast) will occur when these two contingencies influence the same class of behavior (such as pecking). This interpretation is simply that normal positive contrast consists of a combination of instrumental responding appropriate to the schedule of reinforcement (response-reinforcer contingency) and extra responses due to the relation of the signal and reinforcement.

This autopeck explanation leads to some very specific predictions concerned with when contrast should and should not

occur. Since this theory says that contrast occurs only when the stimulus-reinforcer and response-reinforcer contingencies affect the same class of behavior, and since food presentation produces pecking in pigeons, it follows that contrast in pigeons should occur only when a (key) pecking response is used. A number of studies have tested this prediction. Hemmes (1973) demonstrated that contrast would not occur whenever pressing a foot treadle was the appropriate response although contrast did occur with a key pecking response. This result was confirmed by Westbrook (1973).

Another prediction concerns the localization of the discriminative stimuli. Since consistent autopecking occurs only when the stimuli are localized on the response key, contrast should only occur, or at least should be much greater when the stimuli are projected on the key. A study by Redford & Perkins (1974) investigated this by using either key or house light presentation of stimuli and also by using either VI or VT schedules of reinforcement. Results confirmed the prediction. Marked contrast occurred when key light stimuli controlled responding. In addition, Redford & Perkins demonstrated parallel shifts in peck rate during the constant component under VI and VT schedules when key light stimuli were used. This adds further support for the suspected relationship between autopecking and behavioral contrast.

Finally, a study by Keller (1974) seems to provide direct evidence that the contrast effect is due to autopecks or elicited responding. Keller attempted to separate operant and elicited

pecks in a series of multiple schedules by training pigeons to peck a key for food reinforcement while presenting the discriminative stimuli on a second key. Two experiments included two and three component multiple schedules and a comparison of a one or two key procedure. In the first experiment, when the rates from both keys were added together, the results suggested to the author that "... contrast is a phenomenon of elicited and not operant responding (p. 251)." The second experiment used a three component schedule in which baseline training involved a mult VI VI EXT schedule while the contrast phase consisted of a mult VI EXT EXT schedule. Again, when the response rates from the two keys were added together, "... the result is similar to the positive contrast typical of single-key multiple schedules (p. 255)."

This study is, however, not without faults. Keller appears to have made some strong statements. For example, in the first experiment, Keller states that the data support the theory that contrast is due to elicited responding; however, two of the three subjects did not respond in a manner predicted by the theory. Commenting on the data of the second experiment, Keller, states that when the operant and elicited pecks are added, the result is similar to positive contrast. Although, upon examination of the data, the rate changes are in the appropriate direction, the "contrast" effect is typically quite small and not at all in the magnitude of the usual contrast effect. A recent study by Schwartz (1975), however, using the same technique, has provided much more convincing evidence to support Keller's statements.

The study proposed here ia an attempt to test this autopeck explanation of contrast in another manner. The hypothesis states that contrast is due to the addition of autopecks resulting from the stimulus-reinforcer relationship to the normal instrumental pecks. Virtually all studies of contrast begin with instrumental pecking in a multiple schedule with nondifferential reinforcement. Then, the subjects are given discrimination training and it is here the autopecks are added to instrumental responses according to the theory. The first experiment will begin with subjects autopecking in a nondifferential reinforcement situation with respect to chromatic stimuli. Following this training, a discrimination procedure will be introduced in which all pecking will continue to be the result of autopecking. According to the theory, contrast cannot result in this situation. What this study will basically do is to take the autopecks, which are normally added to instrumental pecks to produce contrast according to the theory, and begin with these during the nondifferential phase. When discrimination training begins, contrast should not occur because the autopecks have already been accounted for and cannot, therefore, be added to any other responses to produce the effect. Since this experiment will use discrete trials in order to facilitate original acquisition of autopecks, the original nondifferential phase may be seen as differential training between trial periods and intertrial periods. Thus, while contrast might occur during this first phase of the study when autopecking begins, the autopeck explanation could not handle an increase in this contrast should it occur, when discrimination training is introduced.

A second experiment will also be conducted in which all subjects will be hand shaped to key peck. One group will receive training idential to that of the first experiment except that all grain presentations will be delivered on a response dependent basis. A contrast effect should not be seen, according to the theory, because the baseline nondifferential phase again provides the conditions under which autopecking is expected to occur. It would be difficult for the theory to account for an additional contrast effect.

Another group will receive identical training except that the variable intertrial interval will be replaced by a fixed three sec time out. A study by Perkins et. al. (1975) demonstrated that autopecking will not develop when such a short interval separates stimulus presentations. Therefore, autopecking should not occur in Phase 1. Phase 2, however, does provide the conditions for autopecking and a contrast effect should be observed.

EXPERIMENT I

METHOD

Subjects The subjects were 12 experimentally naive pigeons maintained at approximately 75% of their free feeding weights throughout the experiment.

Apparatus All experimentation was conducted in two identical 3/4 inch plywood operant pigeon chambers with standard relay programming equipment located in an adjacent room. The chambers had internal dimensions of 32 cm X 26 cm X 43.5 cm. A Grason Stadler response key was mounted in the center of one wall 17.5 cm above a wire mesh floor. At no time did pecks on the key result in any type of response feedback. Directly below the key, 5 cm from the floor, was an opening 5.2 cm X 6.4 cm allowing access to a grain hopper. The response key was transilluminated by stimuli projected from an Industrial Electronics display cell equipped with No. 44 miniature lamps. Chromatic stimuli with peak wavelengths of 538 and 555 nm were produced by Kodak Wratten Filters No. 74 and 99. Noise from a ventilation fan was continually present in the chamber to mask extraneous sounds. A 7 watt, 100 volt houselight mounted in the upper corner of the chamber opposite the key provided constant diffuse illumination in the chamber except during reinforcement periods when a magazine light operated.

Procedure The subjects were randomly assigned to two groups, a Discrimination (TD) and Nondifferential (ND) Group, with six subjects in each group. Magazine training was initiated by placing a naive bird into the chamber in front of the raised

hopper in which grain was clearly visible. The bird was then allowed to eat for about 10 sec, after which the hopper was made inaccessible. Several unsignalled hopper presentations of about 3 sec duration followed. When the bird consistently approached the hopper during presentations, key peck training (Phase 1) was initiated using the autoshaping procedure described by Brown & Jenkins (1968). A 15 sec illumination of the response key with light of wavelength of either 555 or 538 nm constituted a trial, after which the key light and house light were turned off and the grain hopper presented for 3 sec. The intertrial interval vaired randomly with a mean of 30 sec. In no instance did pecks either during the trial or the intertrial interval have any effects. The two stimulus wavelengths were presented 30 times each in quasi-random order with the restriction that no more than two S1 or S2 periods appear successivley. Reinforcement followed both stimuli 100% of the time. Sessions continued in this manner until the response rates stabilized for both stimuli for five consecutive days. Following this, subjects were placed in the next phase of training.

In Phase 2, subjects in the TD Group were given discrimination training between the 555 and 538 nm stimuli. This was done simply by reducing to zero the percentage of trials reinforced following the 538 nm stimulus. Sessions were run in exactly the same manner as in Phase 1 with 15 sec stimulus presentations and a varying 30 sec intertrial interval.

Subjects in the ND condition were run exactly as in Phase 1 except that the intertrial interval was lengthened to one minute.

This controlled for the doubled time interval between reinforcements in this phase for the TD Group. Again, pecks had no effects whatever. Phase 2 lasted for 15 sessions after which subjects moved to Phase 3.

In Phase 3, conditions were the same as in the first phase for both groups. Birds in the TD condition again received reinforcement after 100% of the trials and ND birds were also placed back on a 30 sec intertrial interval. Subjects remained in this condition for at least 5 sessions.

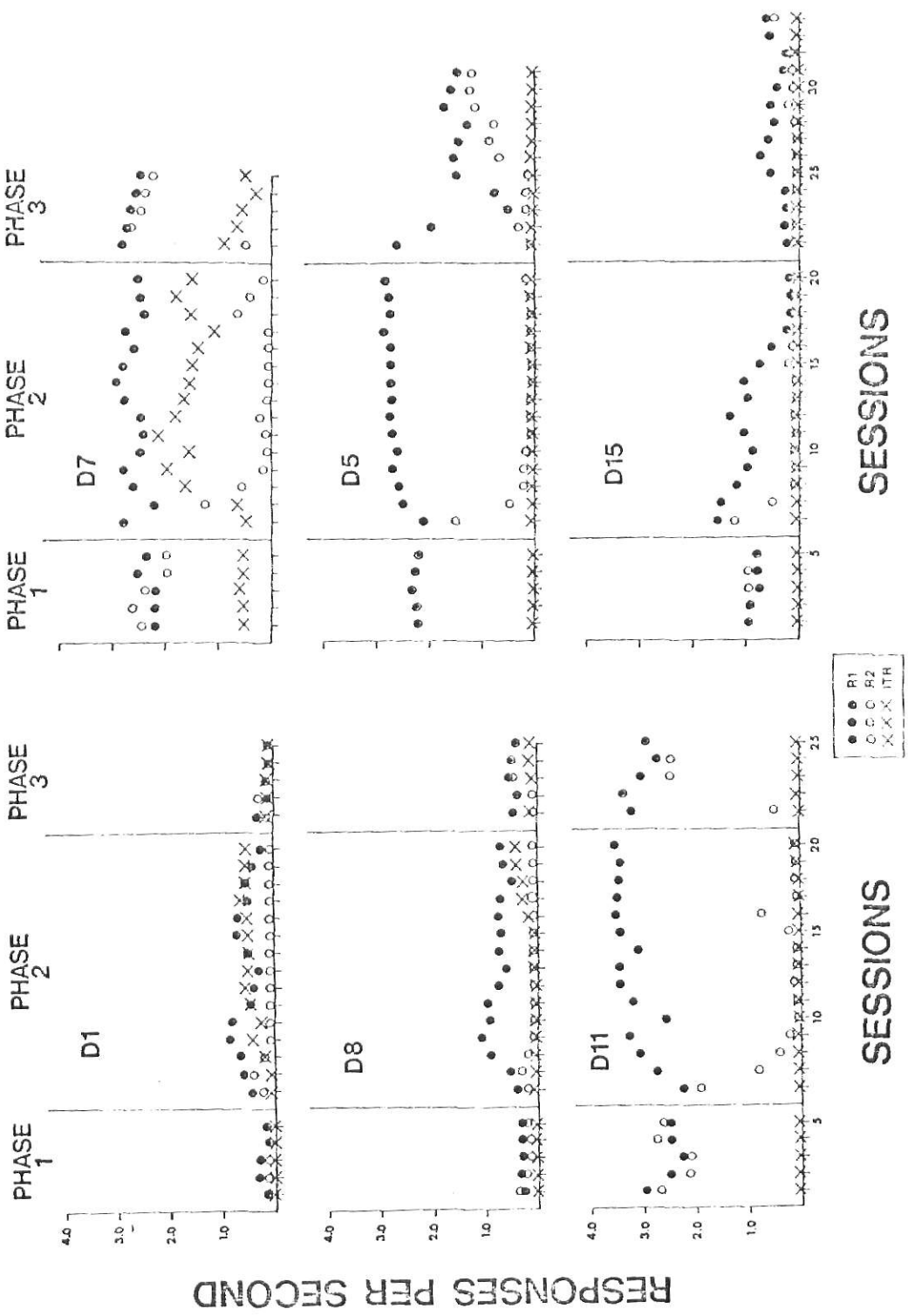
RESULTS AND DISCUSSION

Use of the autoshaping procedure resulted in all birds acquiring a key pecking response. Rates of key pecking in responses per second for each phase of training are presented in Figure 1 for all subjects in Group TD. Phase 1 consisted of nondifferential training between the two chromatic stimuli. A discrimination was established in Phase 2 by reducing to zero the reinforcement frequency in the presence of one of the stimuli. Phase 3 training was identical to that of Phase 1. As can be seen in the figure, five out of six subjects showed an increase in rate of responding to the positive stimulus (S1) during the discrimination training phase with respect to the last 5 days of baseline or Phase 1 responding. When baseline conditions were reinstated, five out of six subjects showed a decrease in their response rate while subject D15 actually showed an increase. In addition, all subjects in this group decreased responding to the negative stimulus (S2) until virtually a zero rate of response was achieved. While these results seem to indicate that contrast occurs while the subjects are autopecking in a discrimination situation, there is one factor which might account for the data and would prevent the use of the term "contrast" in this situation.

One of the changes the birds encountered when first given discrimination training is that the time interval between grain presentations is approximately doubled. Since no grain was presented following S2, the amount of time between food presentations now averaged one minute. It is possible that this factor

Figure Caption

Figure 1. The rates of key pecking during S1, S2 and the intertrial interval for all subjects in Group TD of Experiment I. Each graph is divided according to the three phases of the experiment.


PHASE 1
PHASE 2
PHASE 3
D1
D7
D8
D5
D11
D15
RESPONSES PER SECOND
SESSIONS
SESSIONS
R1
R2
ITR

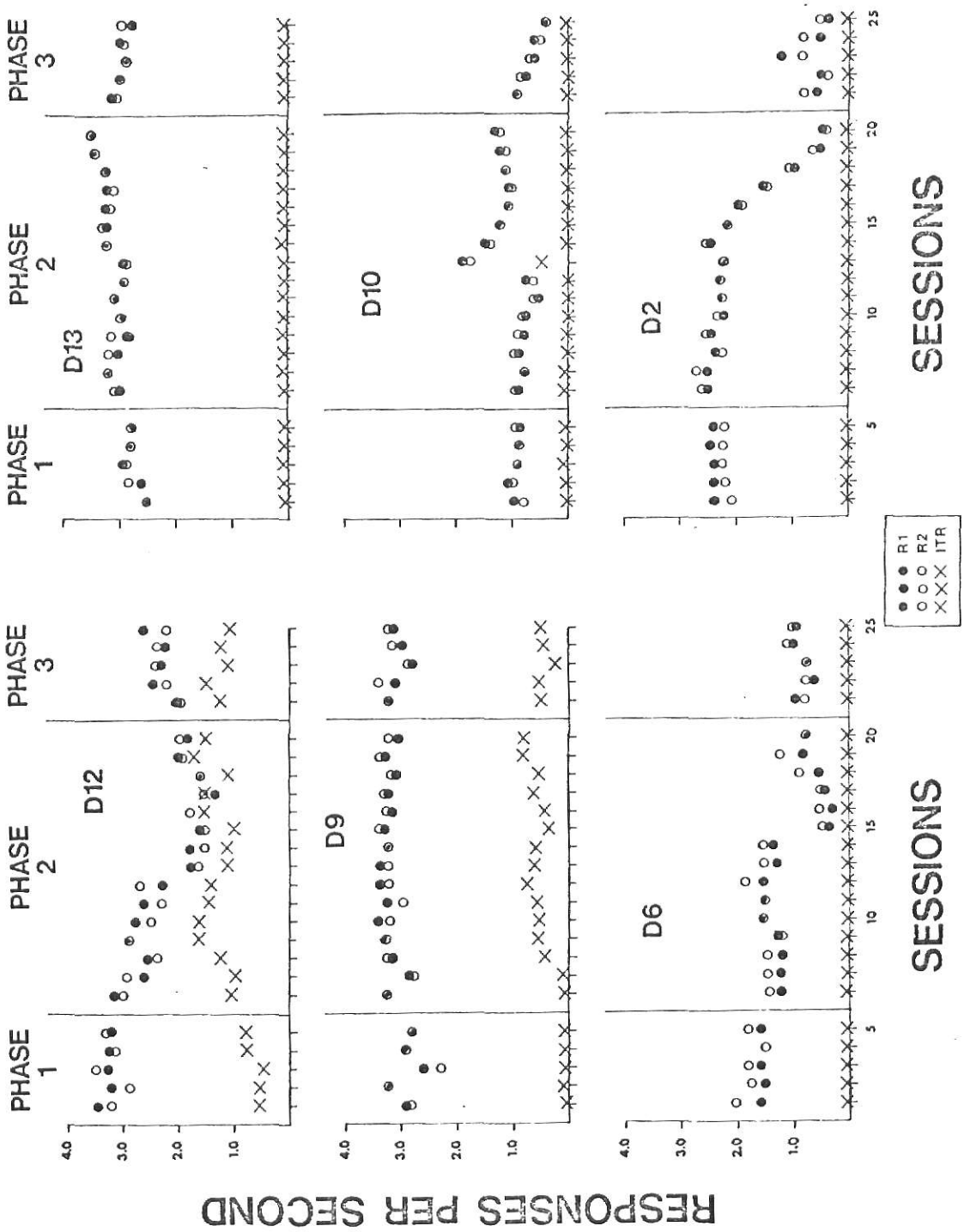
alone would result in an increased response rate to S1 and that discrimination training itself had no effects. If this were the case, the term "contrast" should not be used to describe the results of the TD group. Therefore, Group ND was employed in this experiment to control for the effects of time interval between reinforcements. This group received Phase 1 and Phase 3 training identical to that of Group TD. The difference, however, was that Group ND was maintained on the nondifferential condition in Phase 2, but with a variable time one minute (VT 1 min) intertrial interval instead of discrimination training. This intertrial interval was double the VT 30 sec of Phase 1. Results shown in Figure 2 indicate that only three of six ND subjects (D9, D10, and D13) showed any increase in response rate during S1. The remaining three subjects decreased responding to S1 at one time or another during Phase 2. Finally, there is no evidence of systematic change of intertrial interval rates for subjects in either group.

The results of the TD group would be termed contrast only if a statistically significant difference is found between it and the ND group. For every subject a difference score was obtained by taking the mean positive rate of the fifteen Phase 2 days and subtracting from it the mean response rate from the last five days of baseline training. These difference scores were then submitted to a t test with the results, $t(10) = 2.15$, $p \leq .05$, indicating that no significant differences were found.

Because no precedence has been established concerning the use of statistics in contrast studies, the data from this

Figure Caption

Figure 2. The rates of key pecking during S1, S2 and the intertrial interval for all subjects in Group ND of Experiment I. Each graph is divided according to the three phases of the experiment.


PHASE 1
PHASE 2
PHASE 3
D13
D12
D10
D9
D6
D2
RESPONSES PER SECOND
SESSIONS
SESSIONS
R1
R2
ITR

experiment were also submitted to another statistical test. In this case, the test was based on the frequency of subjects showing a significant increase in response rate when Phase 2 was introduced. For every subject, the mean and standard deviation for S1 responding during the last 5 days of baseline training were calculated. A subject was considered to have significantly increased response rate if at least 1/2 of the rates in Phase 2 are greater than or equal to the mean of these baseline rates plus three standard deviations. This measure accounts for the variability of the baseline in that a subject with a highly variable baseline would have to show a larger increase than a subject with a stable baseline. With this criterion, four subjects in the TD group (D1, D5, D8 and D11) showed a significant increase while only one bird from Group ND (D13) had the required increase in response rate. A Fisher's probability test of these frequencies resulted in $p = .114$, which further supports the results of the t test.

Since no statistical difference between the groups was found, the results of the TD group should not be referred to as contrast. This finding is not inconsistent with the autopeck explanation. Since the birds in the TD group were autopecking before discrimination training began, the autopecks were accounted for in baseline sessions and the hypothesis could not have predicted or explained a contrast effect in this situation. Therefore, a second experiment was conducted using operant pecking in a further test of the autopeck explanation.

EXPERIMENT II

Since contrast did not occur in the TD group of Experiment I, this experiment was conducted to further test the autopeck explanation of contrast. Three groups of subjects were run and reinforcement was response dependent, that is, reinforcement was not delivered unless the subject made the response of key pecking. For two groups, the same parameters as Experiment I were used, i.e., a 15 sec stimulus presentation and an intertrial interval with a mean of 30 sec. These two groups were Discrimination (TD-1) and Nondifferential (ND) Groups and they were run in exactly the same phases as in the first experiment. The only difference between these groups and those of Experiment I is that reinforcement was response dependent with this procedure and, therefore, instrumental pecking occurred. However, since the procedure is the same as that of the first experiment, we must assume that autopecks occurred in the first phase here. In other words, Phase 1 can be viewed as a discrimination procedure in which the subject learns that stimulus presentations predicted the occurrence of reinforcement while the intertrial interval predicted the nonoccurrence of reinforcement. Under such conditions, autopecking will occur as is demonstrated in the first experiment. Since the two groups in this experiment were run under the same conditions, autopecking can be expected to occur in the first phase. There is, however, no distinction between the instrumental pecks and autopecks. When the TD-1 group was switched to discrimination training, the rate of instrumental responding should have remained the same for the stimulus

associated with reinforcement. Any change in the rate of autopecking, therefore, must parallel that shown in the TD group of Experiment I if the autopeck explanation is correct. Since contrast did not occur in that experiment, contrast should not occur for the TD-1 group. Should it occur, however, the autopeck explanation could not handle the data, and this along with the Gynther (1957) study would support the notion that contrast does not occur when a classical conditioning procedure is used. In addition to the two groups described above, a Second Discrimination (TD-2) Group was also run in which a strict multiple schedule was used with only a 3 sec time out separating the stimulus periods. A 3 sec time out is not of sufficient duration to allow for the development of autopecking. The autopeck explanation, therefore, predicts that contrast will occur with this group because autopecks were not generated in Phase 1, but, Phase 2 would provide the conditions for autopecking, and contrast should be observed.

METHOD

Subjects Eighteen experimentally naive pigeons maintained at approximately 75% of their free feeding weights served as subjects.

Apparatus Three operant chambers identical to those of Experiment I were used.

Procedure All subjects were randomly assigned to either a TD-1 group, an ND group or a TD-2 group. Magazine training was the same as that described in the first experiment. However, subjects were hand shaped to key peck using the method of successive approximations. Following this training all subjects were given 30 reinforcements on a continuous reinforcement (CRF) schedule. On the following day, subjects again received 30 reinforcements on a CRF schedule. On the third day, the response requirement was gradually increased until an FR 10 schedule was met and the subjects received 30 reinforcements. During this pretraining, a light with a wavelength of 555 nm was projected on the key.

On the following day, Phase 1 training was introduced. For the TD-1 and ND groups, sixty presentations of a 15 sec trial with a mean intertrial interval of 30 sec constituted a session. Subjects in the TD-2 group received 15 sec stimulus presentations, separated by a 3 sec time out instead of a 30 sec intertrial interval. Responses for all groups were reinforced on a VI 15 sec schedule and there were 30 presentations each of either a 555 or 538 nm stimulus light presented in quasi-random order with the restriction that no more than two S1 or S2 periods appear

successively. Reinforcement consisted of a 3 sec presentation of the grain hopper. Any reinforcements set up but not collected by the end of the stimulus presentation were lost to the subject. Phase 1 continued until response rates to both stimuli stabilized for five consecutive days after which Phase 2 began.

Discrimination training began in Phase 2 for the TD-1 and TD-2 groups with the 555 nm stimulus continuing to be reinforced on a VI 15 sec schedule while the 538 nm stimulus was correlated with extinction. Presentations continued to be of 15 sec duration for both groups while the TD-1 group continued to use a mean intertrial interval of 30 sec. The ND group continued to be reinforced on a VI 15 sec schedule for both stimuli, however, the intertrial interval was increased to one minute . This phase continued for 15 days after which subjects in all groups were returned to Phase 1 training for a period of at least five days.

RESULTS AND DISCUSSION

Results for all subjects in Groups TD-1 and ND are presented in Figures 3 and 4 respectively. The conditions of the experiment for these groups were identical to those of the groups in Experiment I except that these subjects were specifically trained to emit operant pecks and reinforcement was presented according to a VI 15 sec schedule. The first experiment showed that autopecking occurred during baseline training when two stimuli signal grain presentations and an ITI signals no grain. Since the same situation was presented in this experiment, presumably autopecks occurred during Phase 1 and were simply added to the operant pecks. Thus, when the TD-1 birds were given discrimination training, contrast should not have occurred according to the autopeck theory.

The results obtained are consistent with this theory. Of the six birds in this group, none showed a significant increase as defined by the criterion described in Experiment I, while two of six ND subjects (B20, C4) did. Again, this criterion was that at least 1/2 of the Phase 2 points were greater than or equal to the mean rate from baseline training plus three standard deviations. Introduction of extinction for the TD-1 birds in Phase 2 produced a decrease to zero or near zero rates of response in the presence of the negative stimulus. When the groups were given Phase 3 training, little change in rate occurred during S1. TD-1 subjects increased their rate of key pecking during S2 since it was again associated with a VI 15 sec schedule of reinforcement. Rates of intertrial responding for both

Figure Caption

Figure 3. The rates of key pecking during S1, S2 and the intertrial interval for all subjects in Group TD-1 of Experiment II. Each graph is divided according to the three phases of the experiment.

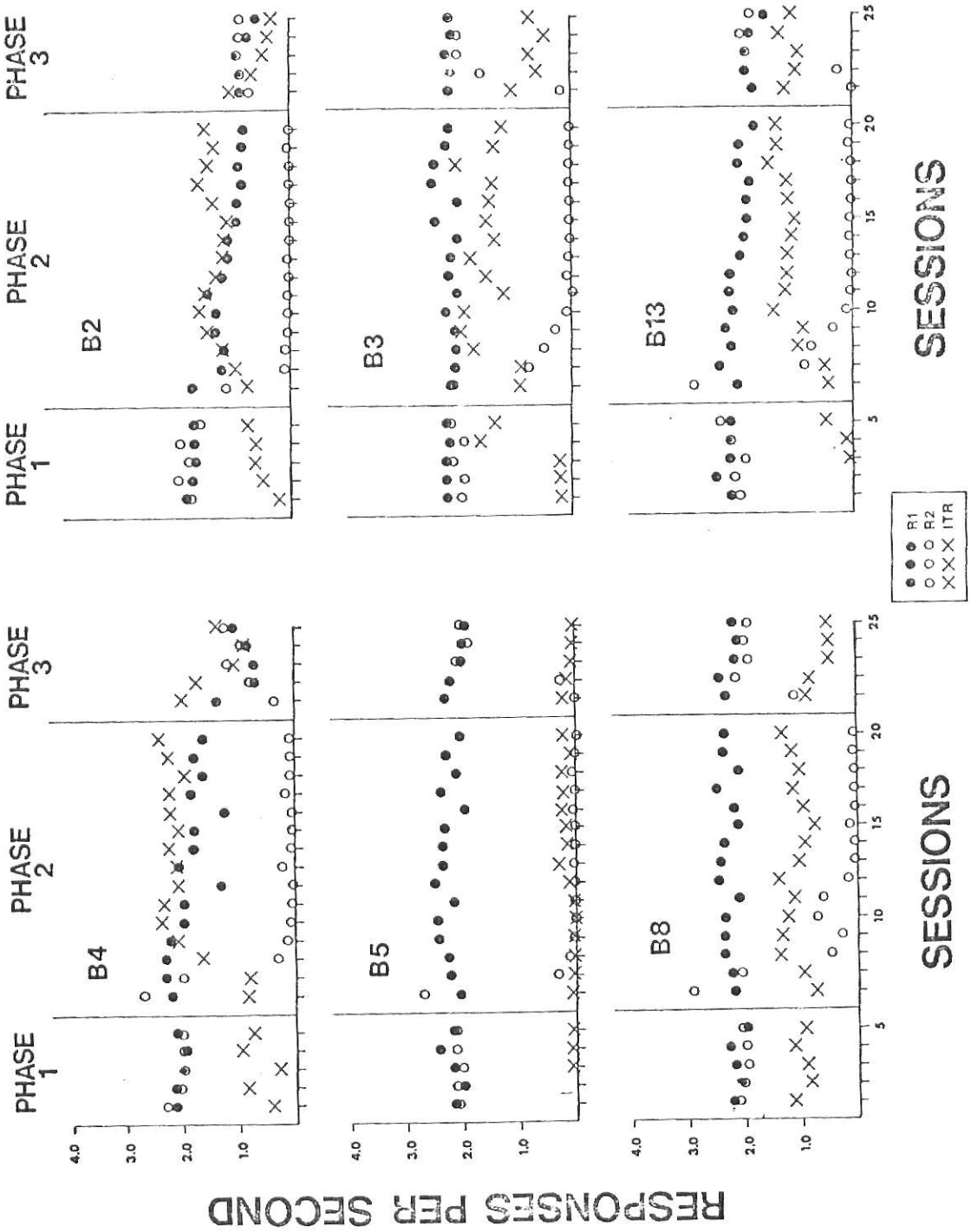
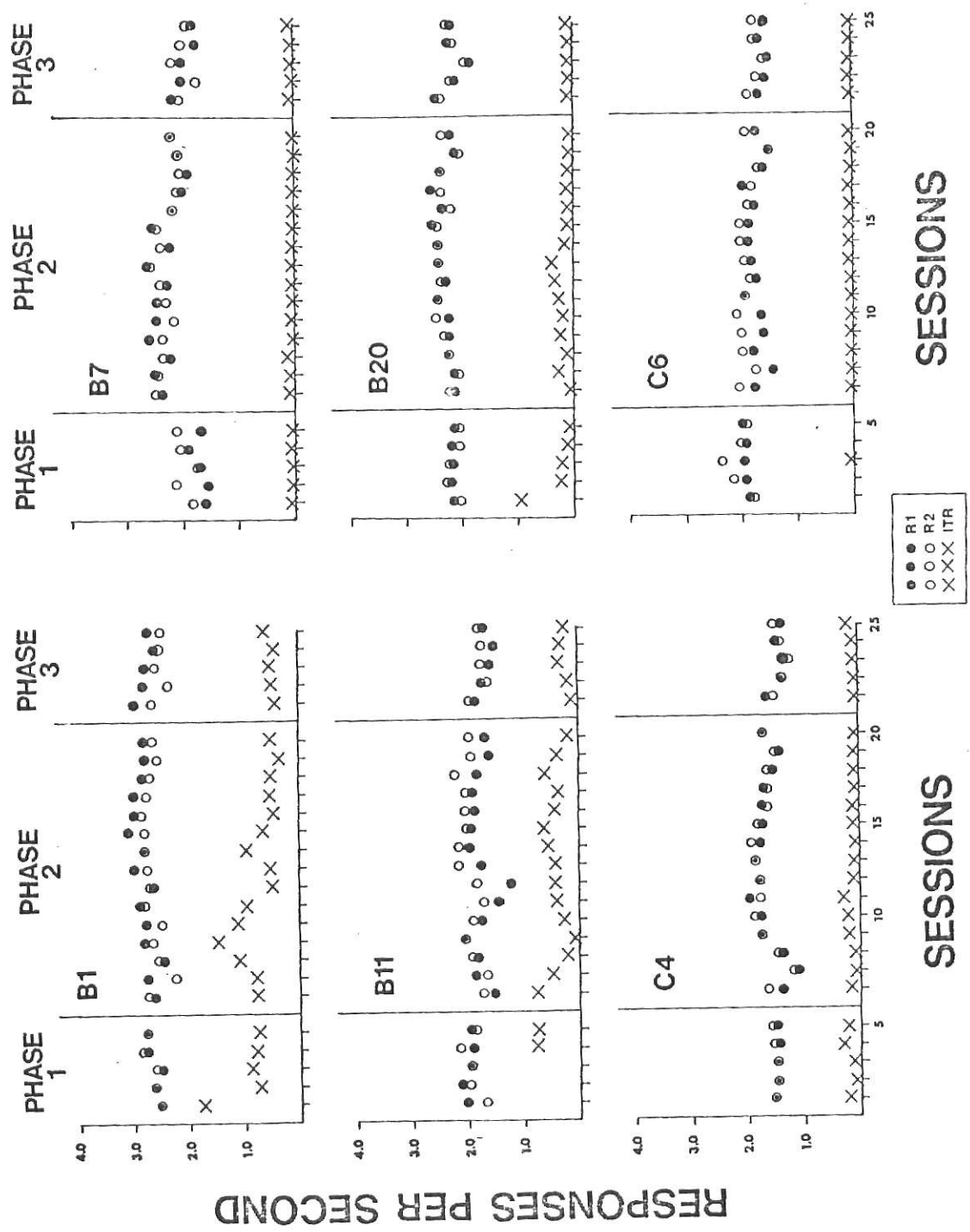

PHASE 1
PHASE 2
PHASE 3
B4
B5
B8
B2
B3
B13
RESPONSES PER SECOND
SESSIONS
SESSIONS
R1
R2
ITR

Figure Caption

Figure 4. The rates of key pecking during S1, S2 and the intertrial interval for all subjects in Group ND of Experiment II. Each graph is divided according to the three phases of the experiment.


PHASE 1
PHASE 2
PHASE 3
B1
B7
B11
B20
C4
C6
RESPONSES PER SECOND
SESSIONS
SESSIONS
R1
R2
ITR

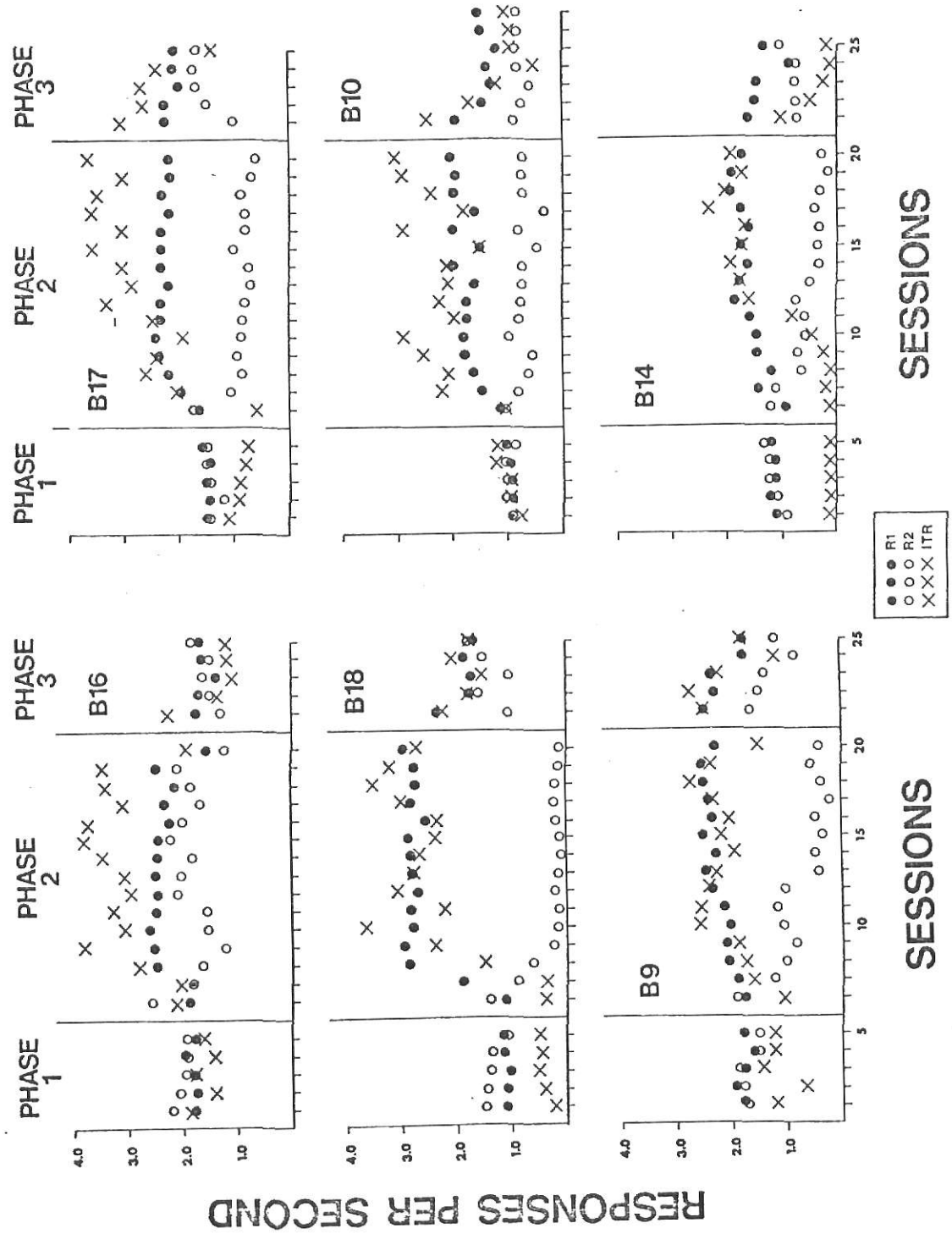
groups showed a large amount of variation with no systematic trends. For some subjects, rates of responding during the intertrial intervals are not shown for the full five baseline sessions due to equipment difficulties.

The third group of Experiment II was a TD-2 group. These subjects were given identical training as the TD-1 group except that a fixed three sec time out separated stimulus presentations instead of a variable time intertrial interval. The purpose of this group was to determine if contrast could be obtained using a typical multiple schedule with 15 sec stimulus periods. Subjects were trained with a mult VI 15 sec schedule during Phase 1 and were switched to a mult VI 15 sec EXT schedule in Phase 2. The three sec time out between presentations is not long enough to permit autopecks to occur in the first phase. But, the introduction of extinction in Phase 2 does provide the conditions of autopecking, and contrast would be expected to occur according to the autopeck theory.

Examination of Figure 5 shows that all birds in the TD-2 group did increase response rate to S1 in the second phase. Application of the contrast criterion reveals that each bird had a significant increase in responding, which would be called "contrast." When the stimulus-reinforcer contingency was withdrawn in Phase 3, rates of response of S1 decreased for all subjects. Again, this result is consistent with the autopeck theory. There were, however, two unusual results associated with this TD-2 group which were not related to the contrast phenomenon. The first involves the poor discrimination

Figure Caption

Figure 5. The rates of key pecking during S1, S2 and the intertrial interval for all subjects in Group TD-2 of Experiment II. Each graph is divided according to the three phases of the experiment.


PHASE 1
PHASE 2
PHASE 3
B17
B16
B10
B18
B14
B9
R1
R2
ITR
RESPONSES PER SECOND
SESSIONS
SESSIONS

performance of the subjects in this group. Although reinforcement never occurred during the S2 component of the second phase, these subjects failed to extinguish as completely as birds in Group TD-1. For example, B16 continued to key peck at a rate of virtually two responses per second despite the absence of reinforcement. Even though the other subjects typically pecked at less than one response per second, only D18 really approached a zero rate.

The second unusual result involved the rate of response during the time out between stimulus presentations. When discrimination training was introduced in Phase 2, every bird showed a very large increase in key peck rate during the time out periods. In addition, these rates typically were greater than or equal to the rates during the positive stimulus. In four of the six subjects, the rate at one time or another reached three responses per second. In all cases, the increase was easily considered significant according to the criterion. Occasionally the three second reinforcement did spill over into the time out period, however, in all cases the reinforcement was gained during S1. Since these spillovers also occurred in Phases 1 and 3, a simple reinforcement explanation is inadequate. It is obvious that this increased rate was in some way due to the discrimination training because these rates decreased for all birds during Phase 3. An hypothesis concerning these two unusual results will be discussed in the general discussion.

The basic results of Experiment II provide further evidence for the autopeck theory of contrast. When autopecking was

expected to have occurred during baseline training (as in Group TD-1), contrast did not occur during discrimination training. However, when conditions were such that autopecking was not expected to develop in Phase 1 (Group TD-2), contrast did occur in Phase 2 under conditions which typically produce autopecking. Finally, when the conditions for autopecking were eliminated (Phase 3), the contrast effect disappeared.

GENERAL DISCUSSION

The main finding of Experiment I is that discrimination training with autopecks in a discrete trials situation does not result in a significant amount of contrast. While subjects in this situation do show an increased rate of pecking, the effect is not as large as that shown in a typical multiple schedule with operant key pecking. In addition, it may be possible to explain this effect on the basis of reinforcement density. The main result of the second experiment is that the operant contrast effect can be eliminated by interposing between stimulus presentations a nonreinforced time out of relatively long duration. The time out used in this case was approximately double the duration of the stimulus presentation. The duration of time out necessary for this reduction of contrast is, however, unknown.

The implications of these results for current theories of contrast will now be discussed beginning with the Amsel (1971) theory. Amsel believes that the frustrative effects of nonreward during the negative stimulus increases the level of responding to a succeeding positive stimulus, presumably due to the excitatory effects of frustration. Therefore, it follows that this should only occur when the time interval between the trials is of short duration. While it follows that Group TD-2 should show contrast, the results of Group TD-1 do provide some difficulty for the Amsel interpretation. Since the VT 30 sec intertrial interval of the TD-1 group is apparently well within Amsel's criterion of a short ITI, he should predict a clear contrast

effect. The results show, however, that none of the six birds in that group gave any indication of contrast. Unless Amsel wishes to exclude key pecking from his interpretation, this study seems to provide definite evidence against his theory.

The theories of Terrace (1972) and Premack (1969) are sufficiently similar to be considered together. The basic requirement for contrast according to these theories is that the negative stimulus must be generating inhibition or aversiveness. That is, the negative stimulus must be aversive enough to produce an inhibitory generalization gradient. As with the Amsel theory, the TD-1 group does not seem to fit into this interpretation. While every subject in this group responded at virtually a zero rate, none of the subjects demonstrated a contrast effect. This negative stimulus must have generated inhibition and yet no contrast occurred. Assuming that there is a negative correlation between amount of inhibition and response rate to the negative stimulus, then subjects in Group TD-2 also present a problem. The higher response rate to the negative for these subjects as compared to those of Group TD-1 should have indicated a greater contrast effect for subjects in TD-1. The obtained results did not match the prediction. While the subjects in TD-1 gave no evidence of contrast, every TD-2 bird showed a clear contrast effect. While these results are contrary to the theories of Terrace and Premack, a few additional principles might explain these results by taking into account the effects of the inter-trial interval.

Another major theory of contrast is that of Reynolds (1961), which emphasizes frequency of reinforcement as controlling contrast. Reynolds feels that contrast occurs when the frequency of reinforcement during a stimulus increases relative to the frequency during all other stimuli that control responding. Thus, in the typical multiple schedule during baseline training, the subject receives 50% of his reinforcements during S1. When discrimination training begins, 100% of the reinforcements are acquired during the presence of S1 and this change in relative frequency is the cause of contrast according to Reynolds. As with the other theories discussed thus far, Group TD-1 does appear to contradict the Reynolds interpretation. Contrast should occur when reinforcement frequency increases relative to the frequency during all other stimuli that control the behavior. Baseline conditions for Group TD-1 can be considered to consist of three alternating stimuli: S1, S2, and the intertrial interval. The relative frequency of reinforcement during these stimuli was .50, .50 and 0.00 respectively. When Phase 2 was introduced, the relative frequencies changed to 1.0, 0.00, and 0.00 respectively. With respect to the other stimuli that control key pecking, the relative frequency of reinforcement during S1 increased from 0.50 to 1.00. Therefore, contrast should have occurred according to Reynolds. Since the rates did not increase, this can be taken as evidence against the Reynolds hypothesis.

A mathematical formulation of contrast also based on frequency of reinforcemtn was developed by Herrnstein (1970). According to this formula:

$$P_1 = \frac{k\ R_1}{R_1 + mR_2 + R_o}$$

where P_1 = rate of responding in Component 1; R_1 = rate of reinforcement in Component 1; R_2 = rate of reinforcement in Component 2; R_o = rate of reinforcement for responses other than those of Components 1 and 2; m = a constant representing interaction of the components. In a multiple schedule $0 \leq m \leq 1$ depending upon the rate of alternation of the components. Rapid alternation increases m. K = a constant equal to P_1 when R_2 and R_o are zero. Contrast is accounted for because of the increase in the relationship between P_1 and R_2. The major difference between the Reynolds and Herrnstein theories concerns the parameter m. This formula predicts that the contrast effect will be larger as the components are alternated more rapidly. Since this would result in a larger m, it would allow R_2 to have more of an effect on P_1.

The results of the current study are consistent with this theory. Since the TD-1 group of Experiment II had a relatively long ITI separating stimulus presentations, m should be quite small and no contrast would be shown. The TD-2 group, however, alternated components much more rapidly and would result in a relatively high value of m. This would account for the large contrast effect shown with this group.

The problem with this formulation involves the three free parameters: K, m, and R_o. Herrnstein has only taken existing data and applied his theory to it. Given an experimental situation, he could not assign values to the parameters and

predict the size of the effect. Prediction could only occur in an ordinal sense. That is, when comparing the designs for different groups, Herrnstein might predict that one situation will produce a greater effect than another. He could not, however, predict the magnitude of the effect. Only when given the results would he attempt to assign values to his parameters to determine if his theory will fit the data.

The present study is consistent with this formulation; however, this study does not provide an adequate test of the theory. Herrnstein typically plots the rate of responding in one component as a function of the proportion of reinforcements in all other components. The current study provides only two points on this graph, with those being 0% and 50% of the reinforcements occurring in other components. With only two points plotted, Herrnstein could easily manipulate his parameters to fit the data.

The present study was undertaken basically as an attempt to test the autopeck theory of contrast as developed by Gamzu & Schwartz (1973), Rachlin (1973) and others. This theory states that contrast is the result of autopecks being added to the operant responses maintained by the schedule of reinforcements. These autopecks are engendered when a stimulus-reinforcer relationship is added to the response-reinforcer relationship. The TD group of Experiment I tested the theory in that autopecking occurred in baseline conditions and was accounted for. Thus, according to the theory, discrimination training should not produce any increase in this rate. While all subjects did

show an increased response rate during discrimination training, this effect might be due to the increased time duration between reinforcements. Therefore, the increased rate of the TD group was not termed contrast and the results did not provide conclusive evidence against the autopeck theory.

In Experiment II, Group TD-1 was given treatment identical to that of Group TD except that TD-1 birds were first trained to emit operant pecks. Since the TD group did not show a contrast effect, and TD-1 subjects were in the same basic situation, then the TD-1 birds should not show contrast to be consistent with the theory. Again, the results fit with the autopeck explanation. None of the subjects in Group TD-1 demonstrated a contrast effect. Another group, TD-2, in this experiment received a typical multiple schedule in which the stimulus-reinforcer contingency occurred only during discrimination training. All subjects in this group showed a marked contrast effect as predicted by the theory.

The results of the present study as well as the results of many studies previously discussed (Gamzu & Schwartz (1973), Hemmes (1973), Redford & Perkins (1974), etc.) seem to provide strong evidence that contrast is the result of autopecking. The theory does not, however, account for the results of Terrace (1968), Hemmes & Eckerman (1972) or Brethower & Reynolds (1962). In the Terrace study, pigeons were given baseline training to a stimulus on a VI schedule of reinforcement. The second phase consisted of a mult VI DRL (differential reinforcement of low rates) schedule in which subjects had to respond at low rates

during the DRL stimulus. Although each bird received approximately 50% of its reinforcements during the DRL stimulus, three of six birds showed contrast. Hemmes & Eckerman (1972) conducted a study using the schedule opposite that of Terrace (1968). After subjects stabilized on a mult VI VI, they were given mult VI DRH (differential reinforcement of high rates) training. Although it should properly be called "induction," the subjects did increase their response rate to the constant component while receiving approximately 50% of their reinforcements during the DRH component. Since no stimulus-reinforcer contingency developed in either study, these results present a problem for the autopeck theory. In the Brethower & Reynolds study, the birds received shock as well as reinforcement for responding to S2. Although this served to reduce response rates, in some cases birds continued to receive 50% of the total reinforcements in the presence of that stimulus. Contrast was shown in these instances although no elicited responding should have occurred, and again, the autopeck theory cannot provide a suitable explanation.

The autopeck theory also had difficulty with some studies which supposedly support it. The Hemmes (1973) and Westbrook (1973) studies both showed that contrast would not occur using a treadle press response while key pecking would result in contrast. Both studies, however, used nonlocalized stimuli (houselight or auditory stimuli) and contrast still occurred. While the amount shown was not great, both authors concluded that contrast occurred. An explanation of these results might

be related to the Schwartz (1973) demonstration that established autopecking could be transferred from key color to tone, and subsequently initiated by the tone. If autopecking can be maintained by a tone, operant shaping procedures could train the birds to direct their elicited pecks at the key. While this could explain the results of the Hemmes and Westbrook studies, it still leaves unanswered the question of why the houselight group in Redford & Perkins (1974) did not show contrast.

As was mentioned earlier, some rather unusual results occurred in the present study with group TD-2 of the second experiment. All subjects in this group showed significant increase in time out response rates when Phase 2 was introduced. The magnitude of these increased rates was such that they were greater than or equal to the response rates in the presence of the positive stimulus. Also, the response rates to the negative stimulus in Phase 2 did not decrease as much as expected. All subjects in Group TD-1 showed virtually a zero rate to the negative while TD-2 birds typically did not even approach this rate.

The hypothesis presented here to explain the unusual TD-2 results is based on the idea that when discrimination training begins, the negative stimulus and the time out change roles. That is, the birds do not respond to S2 as if it were a negative and they no longer respond to the time out as if it were a time out. This hypothesis suggests that the subjects respond to the negative stimulus as though it were a time out in Phase 2. The basis for this contention is a comparison of Phase 1

time out rates with Phase 2 negative rates. Although the match-up is not perfect, in general the rates to the negative stimulus decrease only to the level of the former time out rates. This seems to indicate that the negative stimulus period assumed the role of time out for the subjects in this group.

The way in which these subjects responded to the time outs was suggested in a study by Troutman (1974). Troutman measured the amount of autopecking to a stimulus (which he termed S1) which preceded either a positive or negative stimulus. The probability of either the positive or negative following S1 was 0.5. Thus, the probability that S1 preceded reinforcement was 0.5. Troutman found that the greatest amount of autopecking occurred to the positive and the least amount to the negative, while the amount during S1 was between these rates. His explanation for autopecking to S1 was that its onset produced an increase in the probability of reinforcement from 0.0 to 0.5 as compared to the intertrial interval and that this increase was sufficient enough for autopecking to occur.

Assuming that the Troutman explanation of the development of autopecking during S1 is correct, the present hypothesis suggests that autopecking is responsible for the time out rate increases during discrimination training. During baseline conditions, the probability of obtaining reinforcement in the presence of either chromatic stimulus approached 1.0. Therefore, the probability that reinforcement would follow any time out was approximately 1.0. When discrimination training was introduced, however, the time out periods did signal changes in the probability

of reinforcement. At the end of any trial, the probability that a positive stimulus would follow the intervening time out was 0.5. Thus, the probability that a time out would precede reinforcement was also 0.5. This condition was at least superficially similar to the conditions in Troutman's experiment, and should lead to the development of autopecking. Therefore, this hypothesis suggests that the subjects responded to each time out as though it were an S1 in the Troutman study.

The fact that the time out rates were greater than the positive rates might be explained by looking at the duration of those two periods of time. Although Brown & Jenkins (1968) reported that trial durations of three and eight seconds were equally effective in producing autopecking, Ricci (1973) did find greater autopeck rates to a thirty second stimulus than to a 120 sec stimulus. Also, Shimp & Menlove (1974) reported a larger contrast effect with five second components than with 180 sec components. It is, therefore, conceivable that a three sec component will yield greater rates than a fifteen sec one and this may account for the greater rate of responding to the time out than to the positive stimulus.

What is lacking in this hypothesis is an explanation of why the unusual results occurred at all. If the hypothesis is correct, why would the subjects respond to S2 as though it were a time out and why has this result not been found in other operant studies? One reason is that some studies are conducted without a time out separating stimulus components. For those studies using time outs, the rates of responding are usually

not recorded. In addition, this hypothetical increase in autopecking during the time out may be dependent upon the absolute or relative durations of the various components. Further experimentation is necessary in order to determine the parameters of the effect as well as the exact cause of it.

The present study has indicated that interactions in multiple schedules may be due in large part to the development of autopecking. This study has presented results generally consistent with the autopeck theory of contrast. Contrast occurred only during schedules that are conducive to the development of autopecking. In addition, rates of response during the time interval between stimulus presentations appear to be affected by autopecking, an effect that should be investigated further.

Appendix A

Number of Responses per Session in each Phase of Training for Subjects in Group TD

Subject	Stimulus	Phase 1					Phase 2			
		1	2	3	4	5	1	2	3	4
D1	S1	75	90	89	63	71	166	260	273	333
	S2	73	64	71	60	73	102	164	83	27
	ITI	6	8	7	4	6	12	47	287	696
D5	S1	1011	1041	1061	1044	1010	955	1156	1175	1212
	S2	1000	1019	1049	1029	1005	667	213	113	98
	ITI	46	53	95	47	36	89	28	39	21
D7	S1	999	990	1031	1143	1066	1258	1016	1179	1238
	S2	1093	1178	1061	896	872	1254	579	259	76
	ITI	1007	1048	1145	996	1013	825	1152	2855	3406
D8	S1	134	134	118	94	109	165	254	389	483
	S2	156	111	68	63	94	79	141	86	37
	ITI	26	6	7	67	98	136	70	61	4
D11	S1	1329	1124	995	1124	1125	1015	1237	1389	1482
	S2	1202	952	952	1230	1186	862	377	176	109
	ITI	18	18	29	27	26	59	32	18	12
D15	S1	395	404	318	361	364	704	666	523	434
	S2	410	448	429	423	357	533	211	19	8
	ITI	8	3	7	6	54	34	23	8	8

Appendix A - cont.

Subject	Stimulus	Phase 2 5	6	7	8	9	10	11	12	13
D1	S1	349	215	161	140	227	301	303	217	229
	S2	44	7	32	32	19	14	12	15	9
	ITI	519	801	989	872	804	816	863	1123	955
D5	S1	1186	1208	1227	1209	1214	1218	1226	1292	1241
	S2	75	1	11	5	0	1	2	6	1
	ITI	15	11	17	20	14	21	13	25	34
D7	S1	1113	1073	1101	1241	1310	1271	1173	1229	1069
	S2	42	49	104	37	28	13	14	21	285
	ITI	2744	3746	3131	2859	2613	2592	2387	1893	2624
D8	S1	411	443	346	275	337	307	339	316	236
	S2	17	18	18	8	3	4	4	7	5
	ITI	7	72	38	93	112	148	330	532	524
D11	S1	1175	1438	1540	1541	1406	1535	1599	1575	1559
	S2	8	11	66	11	0	110	324	26	17
	ITI	8	16	11	12	11	22	43	16	16
D15	S1	382	456	586	440	472	318	236	102	45
	S2	1	0	2	0	1	94	53	14	8
	ITI	4	10	9	5	7	6	8	2	0

Appendix A - cont.

Subject	Stimulus	Phase 2		Phase 3						
		14	15	1	2	3	4	5	6	7
D1	S1	167	115	125	115	58	34	62		
	S2	9	10	57	143	59	45	54		
	ITI	998	956	253	225	104	117	58		
D5	S1	1258	1283	1189	871	204	327	651	688	630
	S2	0	63	44	135	61	58	43	299	394
	ITI	25	23	11	11	3	1	7	18	22
D7	S1	1115	1125	1248	1200	1183	1138	1098		
	S2	162	55	189	1186	1088	1062	1015		
	ITI	3047	2562	1535	1091	906	423	799		
D8	S1	298	315	204	160	217	200	157		
	S2	17	3	5	39	211	217	162		
	ITI	640	719	243	81	193	293	196		
D11	S1	1535	1588	1441	1504	1357	1215	1341		
	S2	5	0	247	1500	1119	1109	1310		
	ITI	15	15	10	189	28	22	32		
D15	S1	57	77	94	125	116	116	247	314	269
	S2	1	25	1	1	0	1	10	7	9
	ITI	0	7	1	2	0	1	0	1	1

Appendix A - cont.

Phase 3

Subject	Stimulus	8	9	10	11	12	13	14
D5	S1	583	761	718	657			
	S2	333	517	547	533			
	ITI	19	23	28	23			
D15	S1	196	239	183	141	114	266	277
	S2	39	95	51	75	63	265	227
	ITI							

Appendix B

Number of Responses per Session in each Phase of Training for Subjects in Group ND

Subject	Stimulus	Phase 1					Phase 2			
		1	2	3	4	5	1	2	3	4
D2	S1	1078	1065	1067	1109	1077	1128	1138	1051	1113
	S2	937	984	1021	1026	1008	1174	1206	1033	1162
	ITI	34	39	29	39	39	40	31	31	28
D6	S1	720	676	724	664	724	536	543	535	571
	S2	909	780	809	690	802	634	645	632	554
	ITI	32	27	27	28	20	18	21	19	13
D9	S1	1321	1462	1175	1322	1249	1454	1263	1416	1484
	S2	1276	1472	1036	1300	1264	1466	1222	1462	1477
	ITI	45	74	38	41	95	250	327	1533	2106
D10	S1	441	466	402	403	383	414	318	381	351
	S2	367	443	421	402	434	433	349	434	409
	ITI	17	14	11	9	11	63	40	14	5
D12	S1	1547	1438	1483	1464	1442	1420	1186	1160	1298
	S2	1456	1289	1572	1439	1493	1371	1305	1076	1284
	ITI	1003	975	809	1301	1260	3612	3487	4321	5840
D13	S1	1142	1187	1322	1258	1222	1359	1440	1365	1305
	S2	1123	1274	1296	1261	1265	1397	1462	1462	1434
	ITI	45	40	42	40	38	76	72	116	81

Appendix B - cont.

Subject	Stimulus	Phase 2 5	6	7	8	9	10	11	12	13
D2	S1	1024	1036	1046	1020	1100	977	873	650	460
	S2	1050	1026	1037	1011	1159	980	850	640	481
	ITI	40	31	42	30	33	35	29	24	18
D6	S1	676	674	682	587	602	159	135	182	254
	S2	707	672	825	686	699	202	235	225	386
	ITI	20	7	22	23	23	14	15	8	9
D9	S1	1529	1480	1506	1506	1469	1494	1418	1461	1391
	S2	1451	1344	1459	1477	1459	1525	1481	1495	1428
	ITI	1970	2014	2600	2143	2085	1213	1487	2240	1922
D10	S1	353	245	319	852	648	544	478	492	509
	S2	364	271	281	774	605	556	461	456	502
	ITI	1	0	10	1634	6	4	2	2	1
D12	S1	1247	1185	1038	790	811	738	777	598	722
	S2	1120	1035	1212	746	695	701	795	719	748
	ITI	5820	4971	4746	3940	4032	3394	5473	5270	3846
D13	S1	1345	1389	1330	1347	1476	1463	1485	1475	1481
	S2	1368	1408	1313	1311	1463	1501	1445	1416	1485
	ITI	160	163	58	42	400	79	41	47	50

Appendix B - cont.

Subject	Stimulus	Phase 2		Phase 3				
		14	15	1	2	3	4	5
D2	S1	230	204	272	198	553	252	161
	S2	282	174	334	179	375	368	247
	ITI	8	2	4	1	11	7	2
D6	S1	369	317	429	278	332	446	433
	S2	533	344	361	346	334	498	462
	ITI	20	25	16	16	17	22	26
D9	S1	1482	1356	1441	1395	1263	1345	1406
	S2	1510	1472	1467	1530	1280	1420	1461
	ITI	2708	2706	832	909	511	711	896
D10	S1	556	552	407	356	274	273	166
	S2	503	508	436	378	310	241	167
	ITI	5	5	3	5	3	2	0
D12	S1	911	829	905	1096	1043	1003	1173
	S2	884	883	888	1023	1078	1058	1007
	ITI	5958	5486	2161	2564	1858	2090	1850
D13	S1	1547	1570	1429	1349	1304	1358	1266
	S2	1533	1596	1399	1355	1315	1349	1352
	ITI	53	60	45	39	42	38	38

Appendix C

Number of Responses per Session in each Phase of Training for Subjects in Group TD-1

Subject	Stimulus	Phase 1					Phase 2			
		1	2	3	4	5	1	2	3	4
B2	S1	812	782	751	761	755	774	566	541	599
	S2	786	899	821	862	727	500	31	34	15
	ITI	465	867	1156	1071	1293	1292	1755	2219	2542
B3	S1	1016	1032	953	979	969	962	928	927	929
	S2	882	854	913	870	944	949	368	245	142
	ITI	330	394	436	2864	2413	1649	1638	3041	3447
B4	S1	957	960	897	871	937	980	1029	1039	999
	S2	1039	926	889	914	916	1208	865	144	59
	ITI	619	1548	521	1675	1260	1395	1353	2875	3656
B5	S1	961	902	981	1089	973	923	1025	1039	1086
	S2	935	964	907	968	957	1210	141	56	13
	ITI									
B8	S1	1014	931	994	1036	920	1011	1027	1053	1061
	S2	968	920	883	898	944	1313	940	207	142
	ITI	1953	1568	1624	2016	1635	1268	1747	2375	2346
B13	S1	981	1090	1002	989	994	943	1077	1000	1038
	S2	913	965	860	1003	1064	1294	397	348	158
	ITI			44	170	936	759	1047	1774	1630

Appendix C - cont.

Phase 2

Subject	Stimulus	5	6	7	8	9	10	11	12	13
B2	S1	593	641	543	493	500	434	436	391	416
	S2	17	19	11	14	6	7	9	10	10
	ITI	2907	2712	2345	2197	2098	2016	2392	2857	2501
B3	S1	1025	919	995	971	916	1094	914	1115	1111
	S2	61	0	60	34	12	18	20	13	15
	ITI	3356	2178	2702	3220	2387	2818	2665	2458	3698
B4	S1	888	883	595	914	795	798	570	825	743
	S2	39	26	9	111	42	14	13	74	29
	ITI	4123	4103	3607	4166	3962	3584	3949	3891	3452
B5	S1	1103	979	1148	1062	1064	1047	891	1071	965
	S2	0	0	4	3	2	3	33	2	36
	ITI	26	35	225	528	280	301	411	359	425
B8	S1	1058	952	1110	1081	1055	967	1026	1119	963
	S2	314	271	76	36	41	57	11	14	11
	ITI	2282	2018	2472	1867	1727	1246	1695	2046	1785
B13	S1	972	1023	992	903	870	854	866	845	925
	S2	62	21	10	21	17	32	12	13	13
	ITI									

Appendix C - cont.

Subject	Stimulus	Phase 2		Phase 3				
		14	15	1	2	3	4	5
B2	S1	386	385	398	397	428	351	287
	S2	18	6	329	406	428	415	405
	ITI	2350	2799	1942	1189	850	642	573
B3	S1	1031	1020	995	964	1032	907	1007
	S2	13	5	113	738	923	891	992
	ITI	2451	2231	1835	1117	1290	851	1305
B4	S1	807	732	607	341	310	373	476
	S2	25	38	147	370	552	422	571
	ITI	4005	4169	3526	2975	1823	1574	2401
B5	S1	1040	919	1045	1015	952	899	888
	S2	3	1	4	134	969	872	920
	ITI	176	451	425	300	135	80	61
B8	S1	1074	1057	1054	1097	985	955	1017
	S2	21	17	509	972	880	910	879
	ITI	2085	2377	1628	1587	1021	957	1051
B13	S1	927	798	818	869	874	836	729
	S2	29	19	11	126	882	904	834
	ITI	2371	2402	2277	1843	1769	2352	2082

Appendix D

Number of Responses per Session in each Phase of Training for Subjects in Group ND (Exp II)

Subject	Stimulus	Phase 1					Phase 2			
		1	2	3	4	5	1	2	3	4
B1	S1	1145	1187	1143	1243	1226	1180	1214	1080	1250
	S2	1137	1183	1172	1271	1228	1205	1032	1132	1182
	ITI	3000	1237	1547	1408	1252	2673	2814	3819	5282
B7	S1	732	724	764	871	761	1064	1104	1033	1193
	S2	841	954	801	931	964	1153	1101	1058	1066
	ITI	40	28	13	34	33	88	70	418	55
B11	S1	925	962	889	864	885	702	845	823	920
	S2	757	900	895	967	837	765	753	863	904
	ITI				1356	1304	2640	1624	721	292
B20	S1	976	1014	990	982	968	967	960	1023	1027
	S2	921	1039	1035	925	911	1033	931	1026	1050
	ITI	1703	469	476	251	184	299	1067	528	953
C4	S1	705	653	670	658	688	622	511	634	795
	S2	712	673	669	706	725	732	530	650	774
	ITI	416	46	256	540	459	616	132	299	730
C6	S1	820	866	890	873	791	791	652	813	725
	S2	795	970	1052	914	863	905	789	895	893
	ITI			14			62	47	42	58

Appendix D - cont.

Subject	Stimulus	Phase 2 5	6	7	8	9	10	11	12	13
B1	S1	1232	1260	1175	1316	1251	1361	1332	1330	1269
	S2	1109	1223	1213	1221	1230	1229	1284	1225	1200
	ITI	3943	3380	1772	1978	3335	2339	1568	1986	1785
B7	S1	1099	1108	1048	1174	1003	1083	994	935	881
	S2	982	1069	1079	1140	1083	1092	975	951	937
	ITI	45	36	46	24	37	48	28	35	24
B11	S1	771	642	551	790	822	863	847	872	827
	S2	847	775	832	973	968	901	911	918	989
	ITI	1017	1391	1497	1469	2098	2271	1531	1246	2168
B20	S1	1025	1087	1045	1062	1082	1115	1061	1167	1065
	S2	1109	1091	1063	1074	1074	1097	1030	1082	1058
	ITI	878	1016	1159	1230	512	353	240	304	182
C4	S1	792	888	817	847	794	768	747	749	704
	S2	839	812	807	850	867	819	741	743	747
	ITI	958	1111	324	156	169	392	339	188	144
C6	S1	751	869	795	829	847	859	818	894	747
	S2	944	894	827	892	903	914	849	834	760
	ITI	43	41	29	145	39	36	35	148	42

Appendix D - cont.

Subject	Stimulus	Phase 2		Phase 3				
		14	15	1	2	3	4	5
B1	S1	1239	1263	1313	1257	1243	1142	1210
	S2	1165	1176	1179	1051	1163	1117	1108
	ITI	1231	1954	798	903	964	810	1124
B7	S1	930	1023	980	923	912	820	854
	S2	941	1018	929	802	981	907	879
	ITI	28	36	25	23	33	22	22
B11	S1	726	751	844	771	720	677	766
	S2	869	884	875	721	784	770	789
	ITI	1224	676	217	389	622	565	466
B20	S1	949	1014	1114	994	846	997	977
	S2	931	1053	1068	1016	881	973	985
	ITI	150	148	140	89	65	87	133
C4	S1	643	763	742	616	589	627	616
	S2	685	759	716	600	557	610	673
	ITI	98	67	51	42	167	201	335
C6	S1	704	797	759	729	732	798	727
	S2	713	885	848	777	743	822	809
	ITI	37	30	27	12	29	30	23

Appendix E

Number of Responses per Session in each Phase of Training for Subjects in Group TD-2

Subject	Stimulus	Phase 1					Phase 2			
		1	2	3	4	5	1	2	3	4
B9	S1	759	864	811	723	817	806	853	940	952
	S2	754	811	843	691	688	856	578	458	373
	ITI	211	117	248	224	229	184	283	313	329
B10	S1	415	427	437	430	471	502	661	739	802
	S2	432	459	479	462	441	449	366	274	257
	ITI	135	174	166	210	207	181	388	370	455
B14	S1	505	573	513	519	549	438	639	548	657
	S2	413	494	569	576	601	560	511	302	321
	ITI	19	12	24	21	20	23	35	16	46
B16	S1	805	777	797	855	786	840	814	1112	1152
	S2	986	908	880	850	862	1166	805	744	542
	ITI	324	246	313	244	290	378	361	489	677
B17	S1	669	653	691	662	721	746	929	1008	1072
	S2	631	558	644	696	678	778	499	403	442
	ITI	197	163	162	147	132	114	372	471	438
B18	S1	489	484	457	510	486	479	852	1287	1318
	S2	669	632	609	600	472	608	401	270	107
	ITI	33	68	94	76	81	65	63	273	424

Appendix E - cont.

Phase 2

Subject	Stimulus	5	6	7	8	9	10	11	12	13
B9	S1	917	967	1053	1105	1036	1129	1052	1077	1127
	S2	486	532	460	180	221	150	209	105	158
	ITI	459	460	418	404	343	388	362	413	484
B10	S1	812	778	772	743	879	688	894	737	901
	S2	442	353	339	333	326	210	370	157	315
	ITI	510	349	389	363	375	267	516	320	423
B14	S1	651	725	839	811	748	777	732	801	892
	S2	275	281	339	243	151	178	147	185	145
	ITI	78	149	287	315	348	316	298	422	361
B16	S1	1180	1100	1101	1103	1099	1083	1010	1041	956
	S2	696	714	954	906	825	1001	897	747	832
	ITI	540	582	524	538	606	674	657	547	598
B17	S1	1082	1055	1060	1024	1061	1057	1069	1023	1054
	S2	400	397	385	307	337	462	373	385	399
	ITI	353	457	592	514	548	647	549	648	633
B18	S1	1258	1281	1212	1236	1276	1296	1164	1272	1224
	S2	62	61	90	68	35	53	83	101	81
	ITI	647	391	543	495	473	417	412	523	621

Appendix E - cont.

Subject	Stimulus	Phase 2		Phase 3						
		14	15	1	2	3	4	5	6	7
B9	S1	1154	1048	1128	1044	1076	808	804		
	S2	252	180	754	711	626	385	547		
	ITI	415	282	452	488	404	221	323		
B10	S1	883	909	868	654	591	621	564	681	718
	S2	347	328	395	325	270	384	392	386	385
	ITI	515	543	438	297	224	104	163	175	192
B14	S1	867	780	746	683	670	403	607		
	S2	78	134	328	339	360	328	470		
	ITI	312	349	183	90	51	23	34		
B16	S1	1098	717	787	761	616	737	753		
	S2	932	575	588	674	732	707	825		
	ITI	602	336	407	242	197	212	229		
B17	S1	1000	1022	1038	1040	926	974	967		
	S2	312	281	476	709	772	794	766		
	ITI	543	660	552	478	489	428	253		
B18	S1	1234	1330	1052	795	769	838	757		
	S2	58	60	481	726	472	686	791		
	ITI	568	479	399	321	280	368	318		

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A TEST OF THE AUTOPECKING THEORY OF BEHAVIORAL CONTRAST

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ABSTRACT

Two experiments were conducted in order to test the autopecking theory of behavioral contrast. In the first experiment, autopecking was produced in two groups of pigeons by grain presentations in the presence of two stimuli which alternated with varying intertrial periods (ITIs) averaging 30 sec in length. Following this training, one group (TD) was shifted to a discrimination in which grain was presented independent of responding in the presence of one stimulus and no longer presented in the presence of the other. For another group (ND) the situation remained the same except that the duration of the ITI was increased to an average of 60 sec in order to control for the effects of reinforcement density. No differences in the amount of behavioral contrast was observed between the subjects in the ND and TD groups. The procedure for two groups in the second experiment was identical to that of the first except that all subjects were trained to emit operant pecks before training began. That is, grain presentation occurred according to a VI (response contingent) schedule. An additional group was given discrimination training but with a fixed 3 sec ITI. Contrast was only shown in the group given discrimination training using the 3 sec ITI. These results were consistent with the view that behavioral contrast is due to the addition of autopecks to operant responses. Furthermore, the contrast effect is removed if a long ITI is inserted between stimulus presentations.