THE EFFECT OF EXTENDED DISCRIMINATION TRAINING ON

BEHAVIORAL CONTRAST AND THE PEAK-SHIFT

by

Abdul-Aziz A. Dukhayyil

A Thesis Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF ARTS

In the Graduate College

THE UNIVERSITY OF ARIZONA

1972
STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: [Signature]

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

[Signature]  Nov. 8, 1972

JOSEPH E. LYONS  Date
Assistant Professor of Psychology
ACKNOWLEDGMENTS

Thanks are due to Dr. Joseph Lyons for his kind help and valuable suggestions without which this thesis would not have come to light. The help of Drs. Terry C. Daniel and Clinton L. Trafton is also greatly appreciated. W. Klipec helped in setting up the equipment and fixing it when needed.

This acknowledgment will not be complete without mentioning the generous financial assistance from the Saudi Arabian Government through the College of Petroleum (Dhahran, Saudi Arabia).
TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF ILLUSTRATIONS</td>
<td>v</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>vi</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>METHOD</td>
<td>6</td>
</tr>
<tr>
<td>Subjects</td>
<td>6</td>
</tr>
<tr>
<td>Apparatus</td>
<td>6</td>
</tr>
<tr>
<td>Procedure</td>
<td>7</td>
</tr>
<tr>
<td>RESULTS</td>
<td>10</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>25</td>
</tr>
<tr>
<td>LIST OF REFERENCES</td>
<td>33</td>
</tr>
</tbody>
</table>
**LIST OF ILLUSTRATIONS**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The mean responses to $S^+$ for the birds in Group 1 in 5 day blocks</td>
<td>11</td>
</tr>
<tr>
<td>2.</td>
<td>The wavelength generalization gradients for the birds in Group 1</td>
<td>13</td>
</tr>
<tr>
<td>3.</td>
<td>The mean responses to $S^+$ for the birds in Group 2 in 5 day blocks</td>
<td>15</td>
</tr>
<tr>
<td>4.</td>
<td>The wavelength generalization gradients for the subjects in Group 2</td>
<td>16</td>
</tr>
<tr>
<td>5.</td>
<td>The mean responses to $S^+$ for the birds in Group 3 in 5 day blocks</td>
<td>18</td>
</tr>
<tr>
<td>6.</td>
<td>The wavelength generalization gradients for the subjects in Group 3</td>
<td>20</td>
</tr>
<tr>
<td>7.</td>
<td>The mean responses to $S^+$ for the birds in Group 4 in 5 day blocks</td>
<td>21</td>
</tr>
<tr>
<td>8.</td>
<td>The wavelength generalization gradients for the subjects in Group 4</td>
<td>23</td>
</tr>
<tr>
<td>9.</td>
<td>The wavelength generalization gradients for the subjects in Group 5</td>
<td>24</td>
</tr>
</tbody>
</table>
ABSTRACT

Five groups of pigeons (5 Ss per group) were employed to test Terrace's (1966a,b) hypothesis that behavioral contrast and the peak-shift disappear as a consequence of extended discrimination training. Initially, all five groups received the same discrimination training between 555 nm (S+) and 538 nm (S-). Following mastery of this task, subjects were given a generalization test along the wavelength dimension. Subsequently, Group 1 was overtrained with the original stimuli. Group 2 was overtrained on the original S+ (555 nm) and a new S- (a white vertical line). Group 3 continued training on the original S- (538 nm) and a new S+ (the white line). Group 4 received both a new S+ (the white line) and a new S- (60° white line). Group 5 rested. This experimental design permitted us to replicate Terrace's (1966a) study as well as determine whether the S+, the S-, discrimination training per se, or simply the passage of time is critical in producing the overtraining effect. Following each 15 days of overtraining or resting, each subject was given an additional wavelength generalization test. The results failed to show, for any of the five groups, the effect predicted by the overtraining hypothesis. In fact, in many cases the trends were opposite to the expectation of this hypothesis. It was concluded that the overtraining hypothesis is at best limited and needs serious revisions.
INTRODUCTION

Two by-products of traditional discrimination learning, behavioral contrast and the peak-shift, have received a great deal of attention in recent years because of the theoretical controversy over the necessary and sufficient conditions for producing these two phenomena. Behavioral contrast is the increase in response rate to one stimulus (S+, S1) that accompanies the reduction of response rate to another stimulus (S-, S2) as a result of extinction or other relatively "unfavorable" contingencies (Freeman 1971). Elevation of post discrimination generalization gradients relative to that obtained following single stimulus training is also taken as evidence of behavioral contrast (Terrace 1972). The displacement of the maximum point (mode) of the post discrimination generalization gradient beyond the S+ away from the S- is generally referred to as the peak-shift (Hanson 1959).

The first demonstration of these two phenomena following discrimination training was reported by Hanson (1959). This author used the generalization testing procedure developed by Guttman and Kalish (1956) which made it possible to obtain reliable generalization gradients from individual subjects within a single test session. Since then other researchers have shown that behavioral contrast and the peak-shift are reliable phenomena and occur under a wide variety of training and testing conditions (Reynolds 1961; Honig, Thomas and Guttman 1959; Terrace 1964; Lyons and Klipec 1972). See also general reviews by Terrace (1966a, 1972) and Freeman (1971).
Terrace (1966a) has related his work on errorless discrimination learning to the standard error learning data to conclude that both behavioral contrast and the peak-shift are the result of emotional effects which accompany the S- as a result of non-reinforced responding (errors) in its presence. If such errors do not occur, as with errorless training, neither behavioral contrast nor the peak-shift occurs (Terrace 1966a). The presence of emotional effects during S- were inferred by Terrace (1966a, 1972) as a result of his observation of the birds' flapping wings and turning away from the key in the presence of S-. Terrace (1971) has also shown that pigeons will work to escape from an error S- but not from an errorless one. Since the presence or absence of these emotional effects, and in turn of behavioral contrast and the peak-shift, are correlated with the presence or absence of non-reinforced responding, Terrace concluded that these processes are functionally related to each other (Terrace 1966b, p. 613). Terrace also concluded that behavioral contrast and the peak-shift will invariably occur together if the emotional properties of S- are present.

Terrace (1966a,-b) further argues that if behavioral contrast and the peak-shift are "a manifestation of 'emotional' responses generated by the aversiveness of receiving no reinforcement, one would expect that after prolonged exposure to S+ and S- in a differential reinforcement procedure [both behavioral] contrast [and the peak-shift] would disappear" (1966a, p. 322; see also Terrace 1966b, p. 613).

To test this hypothesis, Terrace performed four related experiments. The first two were pilot studies and were reported in passing (Terrace 1966a, p. 322 and pp. 328-330). The second two experiments were
reported in somewhat more details (Terrace 1966b). The last two experiments are essentially similar in procedure except that in one experiment repeated generalization testing was administered. The over-training was continued in both studies for 60 days. The effect of overtraining on behavioral contrast was monitored continuously throughout training through changes in rate of response to S+. The repeated generalization testing, on the other hand, permitted the monitoring of the effect of such overtraining on the peak-shift. The correction procedure was used in these experiments. This procedure insured that no less than 30 sec elapsed between the last response to S- (error) and the termination of that stimulus and thus prevented adventitious reinforcement of S- responding by the subsequent appearance of the S+.

The results showed that both behavioral contrast and the peak-shift disappeared by the end of the 60 days of training. Terrace concluded that these results are consistent with his hypothesis regarding the functional relationship between the presence of emotional effects and their effect on both behavioral contrast and the peak-shift.

However, several procedural inadequacies present in this study made conclusions regarding the overtraining effect difficult. First, Terrace failed to include control groups in this study. Since successive reversals of the main variables is not possible in this case, and hence behavioral contrast and the peak-shift could not be repeatedly induced and eliminated, the functional relationship between the independent and dependent variables in these experiments could not have been conclusively demonstrated without the use of control groups. Further, if the emotional responses that cause behavioral contrast and the peak-shift occur to
the S-, over exposure to S- might in itself be a sufficient factor for producing the overtraining effect. Also, there may be some contribution of extended exposure to the S+ in producing the overtraining effect and in addition, discrimination training per se, even to a completely different set of stimuli might lead to the dissipation of the peak-shift obtained from the original test dimension. The influence of the passage of time in the dissipation of emotional effects and their manifestations was also ignored. Finally, Terrace stopped the experiment when both behavioral contrast and the peak-shift disappeared. Apparently their disappearance was assumed to be permanent. However, this assumption is part of the overtraining hypothesis which the study was supposed to verify.

The purpose of the present study was first, to replicate Terrace's (1966a, b) finding and second, to extend these results by including the factors mentioned above. The procedure for Group 1 is similar to that used by Terrace, except that the correction procedure was not used. This, however, should not be significant departure as the correction procedure would be used primarily in the early part of the training. Also, Terrace's hypothesis regarding the overtraining effect was offered as being applicable to all types of successive discrimination training.

Four additional groups were employed. Group 2 was overtrained on a discrimination task employing the same S+ (555 nm) used in the initial training and a new S- taken from a different dimension (a white vertical line). The stimulus control literature indicates that such interdimensional training steepens the post discrimination generalization
gradients around the S+. Therefore, this training should work against the tendency for the birds in Group 2 to show the peak-shift along the wavelength dimension (Lyons 1969). Group 3 was overtrained on the original S- (538 nm) and a new S+ (the white line). If the emotional effects that produce behavioral contrast and the peak-shift are associated with S-, then it would follow that extended exposure to the S- in itself should produce the overtraining effect. However, Terrace (1966b) indicated that the overtraining effect is obtained with prolonged exposure to both "S+ and S- in a differential reinforcement procedure" (1966b, p. 322). How this recommendation would follow from his overtraining hypothesis is not clear. However, Groups 2 and 3 from the present study allowed us to determine the specific role of both the S+ and S- in the overtraining effect. Group 4 was overtrained on a new set of stimuli that were on a dimension different from that of the original stimuli. This group permitted us to investigate the influence of discrimination training per se on the peak-shift obtained from the original dimension. Group 5 received no further discrimination training following the initial training. This group was employed to determine if the passage of time is critical in eliminating the peak-shift. Repeated generalization testing on the wavelength dimension was given to all groups every 15 days.

Also, in order to determine the permanence of the loss of behavioral contrast and the peak-shift, overtraining was continued for a predetermined period of time regardless of whether or not behavioral contrast and the peak-shift disappeared.
METHOD

Subjects

The subjects (Ss) were 25 experimentally naive adult pigeons (mixed strains) obtained from a local supplier. All Ss were maintained at 70-75 per cent ad lib weight throughout the experiment.

Apparatus

The apparatus consisted of two standard key pecking champers (Grason-Stadler Model 1100PB). The internal dimensions of the champers were as follows: width 11 inches, depth 11 inches, height 13 1/2 inches (279 X 279 X 343 mm). All surfaces other than the front panel were grey; the front panel was unpainted aluminum. Floors were composed of wire mesh 1/2 inch (12.7 mm) square. The Ss pecking key of transparent plastic was exposed through a 3/4 inch (19.0 mm) circular opening, placed 6 inches (154 mm) above the floor on the front wall of the box. A 2 by 1 3/4 inch (50.8 X 44.4 mm) aperture, located 3 inches (76.2 mm) below the pecking key permitted Ss access to food on a predetermined schedule. Between magazine cycles, food may be lowered beyond the Ss reach. The food magazine was illuminated by a 10 watt bulb which was lighted whenever the food magazine was raised. A 10 watt bulb (house light) situated in the front panel was used to illuminate the entire box. In line display cells (Industrial Electronics Engineers Model E 4580-104) presented the stimuli which were nine wavelengths (501 nm, 511 nm, 538 nm, 548 nm, 555 nm, 566 nm, 576 nm, 589 nm, and 606 nm). The display cells could
also produce two different orientations (90° and 60°) of a white line on a black background. Masking noise was supplied for the duration of the experiment by a noise generator (Grason-Stadler Model 901B).

Procedure

Upon arrival at the laboratory, Ss were individually caged and allowed free access to food, water, and grit until a stable weight level was obtained. Each bird was then reduced to 70-75 per cent of their free feeding weight at which time training began.

All subjects were magazine and key-peck trained and allowed to obtain 50 continuous reinforcements (CRF) for key-pecking on the first day. Reinforcement consisted of a three sec access to the food hopper which contained a mixed grain pigeon feed. On Days 2 and 3 each bird was given an additional 50 CRF for key-pecking. During the next two sessions the CRF schedule was changed to a variable interval (VI) 15 sec (Day 4) and VI 30 sec (Day 5). The stimulus-on periods were 50 sec in duration and each was separated from the next by a ten sec blackout of the stimulus and "house light." Fifteen such periods were presented during the fourth and fifth sessions. Throughout this preliminary training the stimulus on the pecking key was the 555 nm light.

On Day 6 the number of stimulus-on periods was increased to 30 and the reinforcement schedule was changed to VI one min. For 15 of these periods the stimulus on the key was the 555 nm light while, for the remaining 15 periods the stimulus on the key was a 538 nm light. The stimuli were alternated in a quasi random sequence with the restriction that no more than two S+ or S- periods could occur in succession and
VI one min reinforcement was in effect in the presence of both stimuli. This nondifferential training continued for five sessions and provided the baseline response rate to the 555 nm stimulus against which the effect of discrimination training between the 555 nm and the 538 nm could be judged.

Discrimination training then began with responses in the presence of the 555 nm stimulus (S+) reinforced on the VI one min schedule and extinction in effect in the presence of the 538 nm (S-). Fifteen S+ periods were randomly alternated with the above mentioned restriction with 15 S- periods during each training session. Stimulus-on periods continued to be 50 sec in length and each was separated from the next by the 10 sec blackout. Training continued in this manner until a criterion of ten responses to S+ for each response to S- was obtained.

On the day following criterion performance each bird was given a generalization test along the wavelength dimension. The test stimuli consisted of the nine wavelengths previously mentioned. The nine test stimuli were randomized within a series and five different random sequences were presented to each subject. All testing was conducted in extinction and each test was preceded by a five minute warm-up consisting of three S+ periods alternated with two S- periods.

Following the first generalization test, Phase 2 was begun. In this phase Ss were randomly assigned to one of five groups, 5 Ss per group. All Ss, except Ss in Group 5 which rested, received 105 days of further training using the 50 sec stimulus-on time-10 sec blackout procedure. Group 1 received the same condition as before. Group 2 was
given a new S− (90° line), the S+ (555 nm) remaining the same. Group 3 was given a new S+ (90° line) but the S− remained the same. Group 4 was trained to discriminate between a new set of stimuli: S+ 90° and S− 60° lines. In this phase all groups were on a VI one min schedule of reinforcement in the presence of S+ and extinction correlated with S− (mult VI 1 EXT). After every 15 days of Phase 2 training, or in the case of Group 5 resting, a wavelength generalization test similar to Test 1 was given to all Ss, preceded by the five min warm-up to the original stimuli. Each S received a total of eight tests.
RESULTS

It should be noted at the outset that a sufficiently long baseline response rate to the S+ was not obtained in the present study. The interest in this study is focused on whether or not response rate to the S+ would change systematically as a function of extended discrimination training. Hence, it was felt that behavioral contrast data could be evaluated without reference to a baseline measure since specific changes in the rate to S+ would be predicted by Terrace's theory. Therefore, the average response rate to S+ for the first five days of discrimination training is taken as the reference point so that subsequent levels of responses that fall above it indicate the presence of behavioral contrast and the levels of responses that fall below it indicate the absence of behavioral contrast. This definition of behavioral contrast is, in effect, more stringent than the ones that use as a reference point baselines that were obtained during either single stimulus training (Terrace 1966a, b) or nondifferential training (Reynolds 1961), because it has been repeatedly shown that behavioral contrast occurs early in this type of training (c.f. Reynolds 1961, Bloomfield 1969).

Figure 1 presents the mean responses to the S+ for the birds in Group 1 in five day block. It is clear from this figure that at the end of the study behavioral contrast, as defined above, failed to disappear in this group, only Subject A6 showed a clear progressive disappearance of behavioral contrast. Bird A7 showed a contrary trend; the rate of responding to S+ gradually increased as the training continued.
Figure 1. The mean responses to S+ for the birds in Group 1 in 5 day blocks.
Subject A8 also showed a progressive increase in response rate to S+ throughout most of the training but the response rate to S+ declined abruptly at the end of the study. At this point, the difference between the averages of such responding for the first five days and the last five days is not pronounced. More surprising were the data from Subject A19. A clear disappearance of behavioral contrast occurred at first but in about the last month of the study the rate of responding to S+ increased greatly and more persistently than in the beginning. On the other hand, behavioral contrast failed to disappear at all in Subject A20. In fact, in the last five days the average response rate increased greatly.

Figure 2, which presents the generalization gradients for the birds in Group 1, indicates that all five subjects in this group showed the peak-shift in Test 1, four in Test 2, two in Test 3, four in Test 4, three in Test 5, two in Tests 6 and 7, and finally, three out of five birds showed the peak-shift in Test 8.

The generalization test results of the individual subjects in this group showed that while the peak-shift might disappear in one test it usually reappeared in a later test. Note that in four subjects (A19, A20, A7, and A8), later peak-shifts were stronger, i.e., the difference between the numbers of responses to the S+ and to the peak-shift stimulus were larger than earlier ones. Subject A7, for instance, showed a gradient on Test 4 that was symmetrical around the S+. However, even though the peak-shift was not obtained in the next test (Test 5), the peak-shift was nevertheless obtained in the next three tests (6, 7, and 8),
Figure 2. The wavelength generalization gradients for the birds in Group 1.
and in a stronger form. A similar pattern was obtained from Subject A19. The peak-shift disappeared in Tests 5 and 6 but reappeared later in stronger form in Tests 7 and 8.

The presence of the peak-shift was not necessarily accompanied by the presence of behavioral contrast. For instance, the peak-shift was not observed in Subject A8 in Test 7 even though behavioral contrast was present in the five day block (Block 20) that immediately preceded this test. Conversely, Subject A19 showed a peak-shift in Test 2 yet behavioral contrast was not present in the block preceding it. Also, while Subject A6 showed a peak-shift in both Tests 4 and 5 no behavioral contrast was present in the block immediately preceding these tests.

Figure 3 depicts the mean of responses to the S+ of each five days of training for the birds in Group 2. This group was overtrained on the original S+ with a new S- (a white vertical line). As Figure 3 indicates, two subjects (A11 and A21) showed a progressive decline in their response rate to the S+ so that the average response rate for the last five days of the study for both subjects was well below the average rate for the first five days of discrimination training. There was also a great deal of oscillation in the response rate of S+ by Subject A11. Conversely, Subject A10 showed first a progressive increase in the response rate test that later stabilized at a level that was higher than that of the first five days. However, Subject A10's response rate tended to oscillate too. Subjects A9 and A22 did not show a definite trend and their responses oscillated markedly.

Figure 4, which reveals the generalization test data for Group 2, indicates that the peak-shift was present in four subjects in Test 1.
Figure 3. The mean responses to S+ for the birds in Group 2 in 5 day blocks.
Figure 4. The wavelength generalization gradients for the subjects in Group 2.
This test was given at the end of the first phase in which 555 nm and 538 nm were the S+ and S-, respectively. In Test 2 only one peak-shift was obtained, no peak-shifts were obtained in Test 3, and only one peak-shift was obtained in Tests 4, 5, and 6 (from Subjects A9, A21, and A10, respectively). However, in later tests the number of peak-shifts obtained increased. Three peak-shifts were observed in Test 7 and two peak-shifts in Test 8, with four of the five subjects showing a peak-shift in at least one of these two tests.

The generalization test results of the individual subjects disclosed that both Subjects A20 and A21 showed peak-shifts only once in the second phase, A20 in Test 5, and A21 in Test 7. Subject A9 failed to show a peak-shift in the first test which followed the intradimensional training. Yet this subject exhibited a peak-shift in Test 4 which followed 45 days of interdimensional training, and again in Tests 7 and 8. Also, Subject A10 showed a peak-shift in Tests 2 and 6 that were stronger than the one obtained in Test 1. Subject A11 showed the peak-shift in the first test and in the last test.

The data from this group indicate that behavioral contrast is not a necessary precondition for occurrence of the peak-shift. For instance, Subject A21 showed a peak-shift on Test 5 and Subject A11 on Test 8, yet by that time behavioral contrast had already disappeared in both subjects. Conversely, Subject A10 did not show peak-shifts on Tests 2, 3, 4, and 8 in spite of the continuous and strong presence of behavioral contrast.

The S+ training data for Group 3 is presented in Figure 5. Note that all birds showed an initial increase in their response rate to the newly introduced S+ in the early part of Phase 2, but the response pattern
Figure 5. The mean responses to S+ for the birds in Group 3 in 5 day blocks.
in subsequent sessions varied from one subject to another. Subjects A23 and A24 showed a progressive decline in their response rate with training. Subjects A12 and A13 showed a similar trend, except that at about the end of the study the response rate began to increase again. In Subject A14 the initial contrast failed to disappear.

The generalization test results for this group (Figure 6) indicate that over-exposure to the S− did not result in the permanent disappearance of the peak-shift. In fact, these results suggest the contrary as evidenced by the fact that in the last test four out of the five subjects showed the peak-shift.

Subject A13 came closest to supporting Terrace's overtraining hypothesis in that there was a progressive shifting of the gradient peak back to the S+, so that on Test 7 the gradient was approximately symmetrical around the S+. However, in Test 8 of this subject the peak-shift returned. Subject A14 showed a somewhat similar pattern but by Test 8 the peak-shift returned also, even though in Tests 6 and 7 no peak-shifts appeared.

In general the number of peak-shifts observed in each test of this group was the same throughout except in Test 4, where 3 peak-shifts were observed, and Test 7 in which only one peak-shift was obtained.

The behavioral contrast data for the subjects in Group 4 are depicted in Figure 7. Note that no definite response pattern emerged for Subjects A15 or A17. There was great deal of oscillation in these subjects' response rate to S+. However, it is clear that in these two subject behavioral contrast did not actually disappear, at least not permanently. The response rate of Subjects A25, A26, and A16 did not
Figure 6. The wavelength generalization gradients for the subjects in Group 3.
AVERAGES OF RESPONSES TO S+ PER 5 DAYS (IN HUNDREDS)

Figure 7. The mean responses to S+ for the birds in Group 4 in 5 day blocks.
diminish below the response level of the initial five days of Phase 2. In Subject A16, response rate to S+ during Phase 2 continued to increase and then stabilized to a level well above the level of the first five days in Phase 2. This group was overtrained on a new set of stimuli (90° and 75° lines). This type of discrimination task is typically difficult for pigeons to master, and that probably explains the marked oscillation in the response rate of this group (Terrace 1963).

The generalization test results from Group 4 were inconsistent, as shown in Figure 8. Only two out of the five birds in this group show a peak-shift in the first test. Only one peak-shift was obtained in the last test. However, none of the two subjects showing the peak-shift in the first test showed it in any of the last five tests.

The generalization test results from Group 5 (Figure 9) are similar to that obtained from Group 4 except that in the early tests (1-5) the number of peak-shifts was larger than in Group 4. However, the number of peak-shifts in the last three tests was also low for this group. Since this group received no further training after Test 1, those subjects showing the peak-shifts in the first test should, according to the over-training hypothesis, continue to show it in the remaining tests. Yet only one of the subjects showing the peak-shift in the first test (A18, A27, A29) showed it in the last test (Subject A29).
Figure 8. The wavelength generalization gradients for the subjects in Group 4.
Figure 9. The wavelength generalization gradients for the subjects in Group 5.
DISCUSSION

This experiment presents no evidence that behavioral contrast and the peak-shift disappeared as a result of extended discrimination training. There was no evidence of any systematic effect of prolonged discrimination training on the course of behavioral contrast. Only one subject in Group 1, two in Group 2, and three in Group 3 showed a clear disappearance of behavioral contrast at the end of the training, the other subjects did not. None of the subjects in Group 4 showed a permanent behavioral contrast disappearance. In some of the subjects, in fact, there was a progressive increase in the response rate to $S^+$ with training.

It is interesting to note that the behavioral contrast results obtained from the two intradimensional groups (Groups 1 and 4) were similar in at least two respects. First, most of the subjects in both groups showed an increase in their response rates to $S^+$ with training. The difference in behavioral contrast results between these two groups was limited to the marked oscillation in the response rate of subjects in Group 4, which was attributed above to the possibility that line angle discrimination is difficult for the pigeons to acquire. There was, on the other hand, a great deal of difference between the behavioral contrast result of the intradimensional groups and the interdimensional groups in that the number of subjects showing a disappearance of behavioral contrast at the end of the training was much less in the intradimensional groups than in the interdimensional groups (1 subject
vs. 5, respectively). Furthermore, there were also differences in behavioral contrast results between the two interdimensional groups themselves. First, there was marked oscillations in the patterns of responses to the S+ in four of the five subjects in Group 2, although the trends in these responses are clear in many cases. These oscillations in responses may be related to the administration of the generalization tests which were on the dimension of the S+ and presented in extinction. The nature of this relationship, if any, is unclear and could not be determined readily from the data. Another difference in results between the two groups is that in Group 3 there was almost invariably a sharp increase in the response rates in the early part of Phase 2 that was either followed by a progressive drop in these rates or, in the case of Subject A14, by a sharp drop in the rate followed by a progressive increase in that rate. Apparently, the initial sharp increase is related to the introduction of the new S+ which had a disruptive effect on the performance of most of the subjects, which then was immediately followed by a strong behavioral contrast as evidenced by the sharp increase in response rate. This disruption effect was limited mostly to the first two days in Phase 2 and was thus masked in the graphs (Figure 5) by the subsequent increase in the response rate. Subject A24 is a clear exception. Incidentally, the same disruptive effect was also observed in all of the subjects of Group 4 following the introduction of the new set of stimuli. However, in this group, this disruption continued longer in some of the subjects (e.g., Subject A17) because of the difficulty of the new discrimination task. Also, the
marked oscillations in subsequent sessions, which probably reflect a series of "disruptions," masked the behavioral contrast that followed the initial disruption.

In the present study, as pointed out above, no baseline measure was obtained for the response to S+ because it was not felt to be necessary. The data show the decision to have been valid. The behavioral contrast results are clear enough to preclude the need for a baseline data. For instance, the results from three out of five subjects in Group 1 are clearly contrary to the expectation of the overtraining hypothesis. The response rate to S+ either continued to increase throughout the training or, in the case of Subject A19, increased sharply and more persistently in the last month of training. These results are certainly more definitive than the data that can be evaluated solely on the basis of its relation to the baseline, especially when it has been shown that the stability of a VI baseline is not actually achieved before the 20th or 30th session of single stimulus training (Hearst 1971; Freeman 1971).

Regarding the peak-shift data, the results clearly indicate that prolonged training did not lead to its permanent disappearance. The analysis of variance showed a significant difference between the five groups on the number of peak-shifts observed in Tests 2-8 [F(4,20) = 3.23 P<.05], but further analyses via individual groups comparisons revealed that such a difference is in the opposite direction of Terrace's predictions, in that overtraining in the absence of the original S- has a greater tendency to reduce the peak-shift than does extended training with the S- (see Table 1).
Table 1. The analyses of variance via individual groups comparisons.

<table>
<thead>
<tr>
<th>Group No.</th>
<th>No. of Peak-shifts</th>
<th>Group No.</th>
<th>No. of Peak-shifts</th>
<th>F(1,20)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>21</td>
<td>2</td>
<td>9</td>
<td>6.19</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>2</td>
<td>9</td>
<td>9.67</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>1</td>
<td>21</td>
<td>4</td>
<td>12</td>
<td>3.45</td>
<td>&gt;.05</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>4</td>
<td>12</td>
<td>7.27</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

The peak-shift data across tests were also contrary to Terrace's expectations and inconsistent with his results. Four out of five subjects in Group 1 showed stronger peak-shifts in later tests than in earlier ones, as indicated in the Results section. Also, even when the training makes the occurrence of the peak-shift highly unlikely, more so, in fact, in later tests (Tests 7 and 8) than in the second test which was administered after only 15 days of interdimensional training. From the results of Groups 1 and 2 it looks as though overtraining results not in the dissipation of the peak-shift but in the increase in its strength and frequency.

On the other hand, the peak-shift in Group 3 continued to be as frequent in the last test as in the first two tests. Since this group was overexposed to the S-, it is predicted, on the basis of overtraining hypothesis, that the emotional responses that accompany the S- should adapt out and their manifestations disappear as a result. It is clear that the results from this group did not bear this out.
Conversely, of the five subjects in Groups 4 and 5 showing the peak-shift in the first test, four did not show it in the last four tests, even though neither of these two groups were overtrained on the original stimuli following Test 1. In fact, the total number of peak-shifts obtained in Tests 2 through 8 from the subjects showing the peak-shift in the first test, was considerably less than the number of peak-shifts obtained from the subjects that did not show the peak-shift in the first test (10 peak-shifts vs. 18, respectively; average of 2 vs. 3.6 peak-shifts per subject across the seven tests). These groups were not overtrained on the original stimuli, and on the basis of Terrace's overtraining hypothesis, there would have been no reason for the peak-shift to disappear in the subjects that showed it initially, especially from the subjects in Group 5, which rested during Phase 2.

Terrace has repeatedly maintained (e.g., 1966, p. 615) that behavioral contrast and the peak-shift covary. However, the present results indicate that this is not necessarily the case. The peak-shift might appear in a test even though behavioral contrast was not evident in the period immediately preceding the test. On the other hand, the peak-shift may fail to appear in a test in spite of the fact that behavioral contrast was strongly evident in the training period immediately preceding the test.

Also, Terrace apparently assumed on the basis of both the overtraining hypothesis and the seemingly gradual disappearance of behavioral contrast and the peak-shift that such disappearance was permanent. Hence, he did not continue with the experiment after the two phenomena disappeared. However, as was indicated in the Results section of this paper,
some of our subjects gave a pattern of results that were similar to those obtained by Terrace (e.g., behavioral contrast and/or the peak-shift disappeared), but because the experiment was continued further it was found that almost invariably the two phenomena did return with more training. The permanence of the disappearance of behavioral contrast and the peak-shift is definitely part of the overtraining hypothesis and it should not have been merely assumed, but, rather, experimentally verified.

The present results are not without precedents. Hearst (1971) showed that behavioral contrast did not disappear after 64 days of training. The peak-shift, on the other hand, failed to disappear in one subject out of three. It took this subject longer time than the other two to learn the discrimination task. Hearst unfortunately gave only one generalization test at the end of the study. Had repeated testing been presented, the peak-shift results might have been different and more informative. At any rate, Hearst emphasized that it would be unwarranted to conclude that the absence of the peak-shift in the gradients of the other two subjects is the result of overtraining. The absence of the peak-shift could also be attributed to the fact that the two subjects learned the discrimination task quickly.

Hearst reported that in 1970 Selekman "found no consistent decrease in the level of contrast even after 70 days of wavelength training with a correction procedure analogous to Terrace's" (Hearst 1971, p. 361).
Rilling et al. (1969) found that the level of contrast decreased little or not at all over 60 to 64 days of training. Rilling et al. did not use the correction procedure that Terrace used. However, it should be noted that the inclusion or non-inclusion of the correction procedure should not be important as far as the overtraining hypothesis is concerned. For one, with or without the correction procedure, the S- is aversive, and this is more important to the overtraining hypothesis. In fact, it is possible that the correction procedure is a punishing event, thus rendering the S- more aversive (Bloomfield 1966). Second, the correction procedure will more likely be used in the first few sessions only. Training in later sessions should thus be similar to training without the correction procedure.

Terrace's (1966a, b) own results regarding the peak-shift cast, in fact, doubt on the overtraining hypothesis. Judging by the generalization gradient graphs, the disappearance of the peak-shift was not as gradual as Terrace concluded, and as the overtraining hypothesis predicts. Most notable is the gradients obtained from Subject G 339 (1966b, p. 616). In Test 2 the number of responses to the S+ and to the peak-shift stimulus were about equal. However, in Test 3 the number of responses to the same peak-shift stimulus was considerably larger than the number of responses to S+, the opposite of what Terrace would predict. Also, the peak-shift in the last test for Subject G 355 (p. 616) did not definitely disappear because the number of responses to the peak-shift stimulus was about the same as the number of responses to the S+. The generalization test results from Subjects G 301 and G 305 (Terrace 1966a, p. 330) are also not quite consistent with the expectation of the overtraining hypothesis.
In both subjects, the peak-shift did not quite disappear in that the number of responses to the peak-shift stimulus equals the number of responses to the S+.

In conclusion, our results clearly indicate that both behavioral contrast and the peak-shift are ephemeral phenomena in that there was no consistent pattern detected in their presence or absence either from one day to the other, from one test to the other, from one subject to the other, or from one group to another. In fact, some of these results, as noted above, were opposite to the expectation of the overtraining hypothesis. These results, thus, strongly suggest that the overtraining hypothesis is at best limited especially in light of the fact that in the present study discrimination training was continued for considerably longer time than in Terrace's study.
LIST OF REFERENCES


