THE EFFECT OF GRADUAL LENGTHENING OF S- ON BEHAVIORAL

CONTRAST AND THE PEAK-SHIFT

by

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I hereby recommend that this dissertation prepared under my direction by Abdulaziz Abdullah Dukhayyil entitled THE EFFECT OF GRADUAL LENGTHENING OF S- ON BEHAVIORAL CONTRAST AND THE PEAK-SHIFT be accepted as fulfilling the dissertation requirement of the degree of DOCTOR OF PHILOSOPHY.

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SIGNED: A.A. [Signature]
Dedicated to my father

whose use of behavioral contingencies and modeling

made it possible for me to reach this stage!
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1. Total number of errors per subject ........ 17
best an equivocal effect on the absence of behavioral contrast and the peak-shift.
ABSTRACT

The purpose of the present experiment was to test the assumption that the critical factor in errorless training responsible for the absence of behavioral contrast and the peak-shift is the gradual lengthening of S− rather than the absence of errors.

Four groups of pigeons (4 Ss each) were used. In the Early and Late Gradual Groups, the S− was lengthened gradually until its duration equalled that of the S+. In the Early and Late Abrupt Groups, the S− was introduced at full duration from the start. The baseline data were collected either before (in the Late Groups) or after (in the Early Groups) the discrimination training. For the Early Groups the same discrimination task was introduced again after the baseline. In this phase the S− was introduced abruptly even for the Early Gradual Group. The generalization test was given to each subject fifteen days after the S− was first introduced.

The results indicated that on the one hand behavioral contrast was frequently present in all the groups regardless of the experimental condition, but on the other the peak-shift was obtained most frequently in the Late Abrupt Group. Thus, the gradual lengthening of S− had at
INTRODUCTION

Terrace (1963a, 1963b, 1964) found that with a special training procedure which insured that responding to the stimulus associated with extinction (S-) did not occur (errors), both behavioral contrast (i.e., the increase in response rate to the S+ that accompanies the introduction of S-) and the peak-shift (i.e., the shift in the mode of responses during the generalization test away from S+ so as to be further removed from S-) also failed to occur. Terrace (1964, 1966a, 1966b, 1966c, 1968, 1971, 1972a, 1972b) attributed the absence of behavioral contrast and the peak-shift to the absence of errors. He pointed out that the lack of errors per se is the critical factor since in the error groups behavioral contrast and the peak-shift were always obtained. According to Terrace, the occurrence of errors renders S- aversive which in turn produces both behavioral contrast and the peak-shift.

In Terrace's progressive errorless procedure, the S- is gradually lengthened in three phases. First, while the key was dark, the S- is gradually lengthened from 1 sec (Terrace, 1971), 2 sec (Terrace, 1964), or 5 sec (Terrace, 1963a) to 30 sec in duration. After gradually increasing the S- brightness to full intensity, during which the S- is kept at 1 sec duration (Phase 2), the S- is again gradually
lengthened to 30 sec. In the third phase, the duration of both the S+ and S- are lengthened from 30 sec to 90 or 180 sec. If the animal responds to S-, the same duration is repeated during the next presentation of S-.

The present author, however, has argued for an alternative explanation of Terrace's results (Dukhayyil, 1973). I have suggested that the S- becomes aversive relative to the S+ not because of the occurrence of errors but because of the fact that S- comes, with training, to be associated with time-out from reinforcement. Time-out is defined as the discriminated absence of reinforcement or the absence of the stimulus associated with reinforcement (S+). Such discriminated absence of reinforcement renders any stimulus exclusively and consistently associated with it aversive. However, if such an absence is progressively introduced by increasing S- duration, as in the errorless procedure, the aversive properties of the S- may not develop. There are two reasons for this assumption. First, the gradual intensification of an aversive event (e.g., electric shock) has been shown to result in less aversive properties, than when that aversive event is introduced abruptly, especially as evidenced by its punishing effect (Azrin and Holz, 1966; Miller, 1960). Second, and perhaps more importantly, the gradual lengthening of S- may preclude it from signalling the long time-outs and hence make it less aversive relative to an abruptly introduced time-out.
In other words, since short time-outs are relatively non-aversive, increasing the duration by the addition of small and equally spaced increments may not greatly increase its aversiveness. Even if the gradual increase in duration results in little increments in the aversiveness of S-, it would still be small relative to the aversiveness ordinarily obtained with the abrupt introduction of S-. In addition, the fact that the S- in the early progressive procedure is introduced early in the training may be important (Rilling, Richardson, and Kramer, 1973). Apparently early in the training a reference point has not yet been established in relation to which the reinforcement absence and the stimulus accompanying it becomes more aversive, especially when at the same time the mean delay of reinforcement in the presence of the S+ is being increased (e.g., going from VI 30 sec to VI 1 min).

Incidentally, there are other types of errorless procedures reported by Terrace (the trial procedure and the ad hoc method; Terrace, 1963a, 1963b, 1966b). However, these procedures are irrelevant as far as the present experiment is concerned but their bearing on the time-out hypothesis is discussed elsewhere (Dukhayyil, 1973).

That the abruptly introduced S- is aversive has already been demonstrated. Rilling and his associates (Rilling, Askew, Ahluskog, and Kramer, 1969; Rilling, Richardson, and Kramer, 1973) and Terrace (1971) have shown
that subjects will emit responses whose sole consequence is the removal of $S^-$. Other evidences for the aversiveness of $S^-$ include emotional responses (e.g., wing flapping and turning away from the key during $S^-$; Terrace, 1966a, 1972a), aggressive responses (Azrin, Hutchinson, and Hake, 1966), and CER-like (conditioned emotional response) effect when $S^-$ is superimposed on the $S^+$ (Brown and Jenkins, 1967).

The purpose of the present experiment was to test the assumption that the critical factor in the errorless training procedure responsible for the absence of behavioral contrast and the peak-shift is the gradual lengthening of $S^-$ rather than the absence of errors. Four groups were used in this experiment, with four pigeons in each group. The Early and Late Gradual Groups were roughly similar to Terrace's (1963a) free operant Early and Late Progressive Groups except that the brightness of $S^-$ was equivalent to that of the $S^+$ and was not manipulated. Moreover, no attempt was made to prevent errors throughout the experiment. In these two groups the effect of the gradual lengthening of $S^-$ duration on behavior contrast and the peak-shift can thus be studied in isolation. Two additional control groups were included, the Early and Late Abrupt Groups, which were roughly similar to Terrace's Early and Late Constant Groups. These latter two groups allowed us to assess the effect of timing of $S^-$ introduction on behavioral contrast and the peak-shift.
Behavioral contrast was monitored continuously during training and its presence or absence was determined relative to a baseline that was obtained either before the discrimination training (Late Groups) or after the discrimination training (Early Groups). The use of this latter type of baseline was made necessary by the early introduction of S-. In order to test the reliability of this baseline, the discrimination training condition was reintroduced following the baseline condition in the Early Groups. The presence or absence of the peak-shift was evaluated by the use of a standard generalization test (Guttman and Kalish, 1956) given fifteen days after the S- was first introduced. The test was on the dimension of the two training stimuli.
METHOD

Subjects

The subjects (Ss) were 16 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 279 mm, depth 279 mm, height 343 mm. All surfaces other than the front panel were gray; the front panel was unpainted aluminum. Floors were wire mesh 12.7 square. The S's pecking key of transparent plastic was exposed through a 19.0 mm circular opening, placed 154 mm above the floor on the front wall of the box. A 50.8 by 44.4 mm aperture located 76.2 mm below the pecking key permitted Ss access to food on a predetermined schedule. Between magazine cycles, food was lowered beyond the S's reach. The magazine was illuminated by a 10 watt bulb which lighted whenever the food magazine was raised. A 10 watt bulb (house light) situated behind the front panels illuminated the entire box. In line display cells (Industrial Electronics Engineering
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). These stimuli are assumed to be on an ordinal rather than on an interval scale (c.f. Lyons and Klipec, 1971, for procedure used to produce the wavelength stimuli). 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 by restricted feeding to 70-75 per cent of its free feeding weight at which time training began.

All Ss were magazine and key-peck trained and allowed to obtain 50 continuous reinforcements (CRF) for key pecking on the first day. Reinforcement throughout the experiment consisted of a three sec access to the food hopper which contained a sifted 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 two sec blackout of the stimulus on the key and the 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.

For the Early Gradual Group S- (538 nm) was introduced on day 6. During the first discrimination session, the S- was gradually lengthened in the same general procedure as that used by Terrace (1963a). The S- duration was first increased from 1 sec to 30 sec. The duration of S- was then reduced to one sec and remained there for 15 presentations. In the third phase of this session, S- duration was increased gradually again up to 30 sec. The duration of S+ (555 nm) remained 50 sec with VI 1 min reinforcement available. On day 7 S- was progressively increased from 3 sec to 50 sec so that the last 2 presentations of S- were 50 sec in length. On day 8 S- was reduced to 5 sec but was again increased to 50 sec with each of the last seven presentations of S- 50 sec in duration. On day 9 the duration of S- was increased from 10 to 50 sec and on day 10 from 20 to 50 sec in duration. Following day 10, S- was 50 sec in duration. The alternation between S+ and S- was quasi random throughout this experiment. Discrimination training was continued for 15 days, followed by a generalization test along the wavelength dimension. Following the test, 15 days of single stimulus baseline training to the S+ was given followed by a return to the original
discrimination condition without manipulating S- duration. This last phase was 10 days in length.

In the Late Gradual Group S- was introduced after 25 days of single stimulus training to the S+. The duration of S- was gradually increased in a manner similar to the Early Gradual Group. Generalization testing occurred following 15 days of discrimination training.

The same procedures as in the Early Gradual Group was followed with the Early Abrupt Group except that the S- duration was equal to that of the S+ throughout the discrimination training (i.e., 50 sec).

Finally, the procedure used with the Late Abrupt Group was similar to that of the Late Gradual Group except that the S- was introduced abruptly and its duration was 50 sec from the start.

Each subject was given a generalization test to the wavelength dimension 15 days after the S- was first introduced. 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. The test was conducted in extinction and was preceded by a five minute warm-up consisting of three S+ periods alternating with two S- periods.
RESULTS

The focus of the present experiment is on the effect of gradual lengthening of S- on behavioral contrast and the peak-shift. For the purpose of the present experiment, behavioral contrast is defined as the increase in S+ response rate during the discrimination training phase relative to the average of such rate during the last 5 days of the baseline. The relative response rate to the S+ for the subjects in the four groups as well as the mean relative rate for each of the groups appear in Figures 1 through 4. These relative rates were obtained by dividing each subject's total S+ responses for each day during the discrimination phase by the average of the last 5 days of the baseline condition. Thus, behavioral contrast occurred when the relative rate clearly exceeds 1.0.

It is clear from Figures 1-4 that behavior contrast occurred in all the groups. For example, behavioral contrast was present in three of the four subjects in the Early Gradual Group (Figure 1) during the first S+, S- phase (first 15 days in each figure) and by all four subjects in the second S+, S- phase (the last 10 days in each figure). In the Early Abrupt Group, behavioral contrast was obtained from two of the four subjects in the first S+, S- phase, and from all four subjects in the second (Figure 2). For the
Figure 1. S+ relative rate during acquisition days for the subjects in the Early Gradual Group with the group average included.
Figure 2. S+ relative rate during acquisition days for the subjects in the Early Abrupt Group with the group average included.
Figure 3. $S^+$ relative rate during acquisition days for the subjects in the Late Gradual Group with the group average included.
Figure 4. S+ relative rate during acquisition days for the subjects in the Late Abrupt Group with the group average included.
Late Gradual Group clear behavioral contrast was observed in three of the four birds (Figure 3). Finally, the late abrupt condition produced the most consistent result in that all four pigeons showed strong behavioral contrast.

Figure 5 shows the generalization tests data for the subjects in the four groups. The dashed vertical line within each gradient denotes the S+. The peak-shift is said to occur whenever the mode or peak of responding during the generalization test falls not on the S+ but is shifted from it so as to be further removed from the S-.

Inspection of Figure 5 discloses that none of the subjects in the Early Gradual Group showed the peak-shift and only one subject in each of the Early and Abrupt Groups and the Late Gradual Group showed one. However, all the subjects in the Late Abrupt Group showed the peak-shift.

In the present experiment no attempt was made to prevent errors. But as can be seen from Table 1, the Gradual Groups emitted considerably fewer errors (responses during S-) than the Abrupt Groups. The number of errors emitted by the Abrupt Groups is almost four times the number of errors emitted by the Gradual Groups.

Thus, behavioral contrast occurred in at least some subjects in all groups. However, none of the Early Gradual subjects showed the peak-shift whereas all of the subjects in the Late Abrupt Group showed it, suggesting that behavioral contrast and the peak-shift are not always related.
Figure 5. The generalization test gradients for all the subjects with the group averages included.
Table 1. Total number of errors per subject.

<table>
<thead>
<tr>
<th>Early Gradual Groupa</th>
<th>Early Abrupt Groupa</th>
</tr>
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<tbody>
<tr>
<td>A5</td>
<td>A10</td>
</tr>
<tr>
<td>2613</td>
<td>4715</td>
</tr>
<tr>
<td>A11</td>
<td>A9</td>
</tr>
<tr>
<td>1866</td>
<td>3349</td>
</tr>
<tr>
<td>B4</td>
<td>A5</td>
</tr>
<tr>
<td>1625</td>
<td>207</td>
</tr>
<tr>
<td>A3</td>
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<tr>
<td>278</td>
<td>2459</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Total</strong></td>
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<tr>
<td><strong>6382</strong></td>
<td><strong>1073</strong></td>
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<table>
<thead>
<tr>
<th>Late Gradual Group</th>
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<tbody>
<tr>
<td>A8</td>
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</tr>
<tr>
<td>1832</td>
<td>13283</td>
</tr>
<tr>
<td>A7</td>
<td>A4</td>
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<tr>
<td>1317</td>
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<tr>
<td>1154</td>
<td>7626</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>Total</strong></td>
</tr>
<tr>
<td><strong>5229</strong></td>
<td><strong>43249</strong></td>
</tr>
</tbody>
</table>

aIncludes the first S+, S- phase only.
DISCUSSION

Behavioral contrast was obtained from most of the subjects in all the groups, and, in this respect, the experimental conditions had little differential effect. On the other hand, the experimental conditions appear to have had a differential effect on the generalization tests results. No peak-shift was obtained from any of the subjects in the Early Gradual Group but all of the subjects in the Late Abrupt Group showed a peak-shift. The generalization tests results, thus, are generally in the direction predicted by the time-out hypothesis. Recall the time-out hypothesis stated that the aversiveness of S- is the result of the occurrence of time-out from reinforcement rather than the result of the occurrence of errors. The hypothesis further stated that when such time-out is gradually lengthened in duration, as Terrace (1963a, 1964) did with his errorless procedure, the aversive properties as indicated by the presence of behavioral contrast and the peak-shift may not develop.

The presence of behavioral contrast in the Gradual Groups could be due to one or both factors. First, the S- was lengthened in the present experiment according to a logarithmic scale, rather than in equal steps, as Terrace (1963a) did. The later increases in S- duration, which
were as large as 20 sec, might have represented a large
departure from the early small increases, possibly resulting
in an abrupt-like effect, though probably to a lesser
extent than in the Abrupt Groups. The possible role of this
factor needs to be investigated. Second, the occurrence
of a large number of errors in the Gradual Groups might
have contributed to the presence of behavioral contrast. If
this is so, then a revision of the present hypothesis would
be required taking into account the effect of errors on the
aversiveness of S-. The hypothesis would still maintain
that the aversiveness of S- results from its association
with the absence of reinforcement. But the absence of rein­
forcement may be indicated not only by the passage of time
(time-out) as argued earlier and elsewhere (Dukhayyil, 1973)
or by the occurrence of non-reinforced responding as argued
by Terrace (1966a), but may be produced by either or both
of them. In time-out, non-reinforced responses do not
occur or are not relevant and only the passage of time is
the important element signalling the absence of reinforce­
ment. The extinction operation, on the other hand, involves
by definition the occurrence of non-reinforced responses
(i.e., extinction process) which may themselves indicate the
absence of reinforcement. Hence, either of these two
indicants of absence of reinforcement may result in S-
becoming aversive. Accordingly, even if in the present
study the function of time-out is negated by the gradual
introduction of S-, the occurrence of non-reinforced responding may have been sufficient by itself to signal the absence of reinforcement.

The failure of behavioral contrast and the peak-shift to occur together in the first three groups may indicate that the S- in these groups is only moderately aversive. It has been argued elsewhere (Dukhayyil, 1973) that when the aversiveness of S- is low, behavioral contrast and the peak-shift may not occur consistently so that behavioral contrast may be obtained but not the peak-shift, or vice versa, or both may fail to occur. Another possibility is that contrast and the peak-shift are independent byproducts of discrimination training.

The number of errors obtained from the Gradual Groups was considerably lower than those obtained from the Abrupt Groups. This difference in total number of errors between the Gradual and Abrupt Groups may be due to the manner by which S- was introduced in the Gradual Groups. For the Gradual subjects, S- is relatively short initially. Therefore, early in the training of these subjects, the chances are great that attempts to pick may have been frequently prevented by the termination of S- and the onset of 2 sec inter-stimulus black-outs. Lyons (1969a, 1969b) found that when such black-outs are presented contingent upon S- response attempts, errors diminished or stopped altogether. While in the present study the black-outs were
presented independently, it is possible that the effect may not have diminished completely.

In conclusion, only the peak-shift results appear to be consistent with the results obtained in errorless studies (Terrace, 1964; Grusec, 1968). The presence of behavioral contrast in the Early Gradual Group is not consistent with the prediction of the time-out hypothesis or with Terrace's (1963a) results. However, it should be mentioned that some of this difference between the behavioral contrast results of the present experiment and those reported by Terrace (1963a) may in part be due to the difference in the manner by which the data in the two studies were presented on the figures. For instance, it is possible that if Terrace's behavioral contrast data are transformed in the same manner done here, at least a slightly different picture may emerge.
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