BEHAVIORAL CONTRAST WITH TIMEOUT, BLACKOUT, OR EXTINCTION AS THE NEGATIVE CONDITION¹

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When either a timeout period (darkening the response key) or a blackout period (darkening both chamber and response key) was alternated with a stimulus associated with variable-interval reinforcement, behavioral contrast was obtained. Either peak contrast or maintained contrast occurred, depending on whether or not responding was evidenced during the negative condition. These results are contrary to recent accounts emphasizing the role of non-reinforced responding in the production of contrast, but are consistent with interpretations emphasizing the aversiveness of the negative condition.

Behavioral contrast has been defined as "an increase in the rate of responding in one component of a multiple schedule when certain changes occur in the other component" (Reynolds, 1961). Recent attempts to specify what the necessary and sufficient changes are (Terrace, 1966, 1968) have tended to emphasize the importance of a reduction of the rate of responding in one member of a pair of alternating discriminative stimuli. It has been shown that it is possible to reduce the rate of responding in the presence of one stimulus, without affecting the frequency of reinforcement in that stimulus, by reinforcing a low rate (DRL schedule; Terrace, 1968), by using a punishment contingency (Brethower and Reynolds, 1962; Terrace, 1968), by delaying reinforcement (Richards, 1972), and by various other manipulations (see Terrace, 1972 for a complete review). In all these cases, behavioral contrast was evidenced.

Terrace (1968) suggested the existence of two distinct types of discrimination learning, where behavioral contrast would be expected only in those situations where an actual decrease in the rate of responding in the presence of one of the stimuli occurred. Terrace's second type of discrimination learning refers to those procedures where there is no progressive

decremental change in responding in the presence of one of the stimuli. These include such diverse procedures as errorless discrimination training (Terrace, 1963), where no responses occur in the presence of one of the stimuli and responding is thus not reduced, and procedures such as the tandem reinforcement schedules used by Yarczower, Dickson, and Gollub (1966), and the DRL schedules used by Terrace (1968), both of which resulted in above-zero but constant rates of responding in the alternated stimulus. None of the studies subsumed under this second type of discrimination learning obtained behavioral contrast.

Unfortunately, two studies were not included in Terrace's 1968 analysis that would appear to be exceptions to his second type of discrimination learning. Both Reynolds (1961) and Friedman and Guttman (1965) obtained what appeared to be behavioral contrast when a timeout period (the complete darkening of the experimental chamber) was alternated with a stimulus associated with variable-interval reinforcement. A timeout typically results in a complete and immediate cessation of responding (Ferster and Skinner, 1957). Thus, with no responding or reduction of responding occurring in the presence of a timeout, such studies should be grouped with, but stand in apparent contradiction to, the studies supporting Terrace's second type of discrimination learning.

The Friedman and Guttman study has, however, been criticized by Yarczower, *et al.*, (1966) who argued that the apparent increase in responding in the presence of the positive stimulus might have been a result only of con-

¹This investigation was supported by US PHS Research Grant No. MH17693 from the National Institute of Mental Health. A version of the present data was presented at the 1970 meeting of the Eastern Psychological Association. Reprints may be obtained from the author, Department of Psychology, Vassar College, Poughkeepsie, N.Y. 12601.

tinued exposure to the variable-interval schedule of reinforcement. In fact, Friedman and Guttman's data (page 259, Figure 1) indicate that the five days of variable-interval baseline training given were insufficient to establish a stable baseline against which to assess the occurrence of behavioral contrast. In the one case shown, response rate progressively increases over these first five days, and this increasing curve is continuous with the curve purporting to show behavioral contrast. The Reynolds (1961) study is subject to similar criticism, in that in only one case was there more than four 90-min sessions devoted to baseline determination. Furthermore, a maximum of only six sessions was used for determining whether or not contrast had occurred. The variations in these curves both within and between birds, as well as the manner of presenting the baseline data (see page 62, Figure 1), might lead one to question the validity of concluding that contrast had occurred. It should also be noted that Reynolds' birds had prior experience with a variety of other schedules; how this might have affected their tendency to respond to the positive stimulus is unknown.

A more recent experiment by Vieth and Rilling (1972) attempted to assess the effects of both timeout and extinction as determinants of behavioral contrast, using a within-subjects procedure where each animal was exposed to periods of both extinction and timeout within each experimental session. They found a small amount of behavioral contrast, with the effects of timeout and extinction appearing essentially similar. However, this study is subject to some of the same criticisms as the Friedman and Guttman and the Reynolds studies. In addition, as Vieth and Rilling pointed out, their design makes it impossible to determine the relative contribution to the overall contrast effect of the timeout and the extinction periods separately. That is, the contrast effect could have been due to the presence of the extinction periods alone, and there is no independent evidence that timeout periods can produce contrast.

The present study attempted to test the adequacy of Terrace's formulation of a second type of discrimination learning by unequivocally determining whether or not the alternation of a timeout stimulus with a stimulus associated with variable-interval reinforcement

results in behavioral contrast. It represents a "systematic replication" (Sidman, 1960) of the relevant aspects of the Reynolds, the Friedman and Guttman, and the Vieth and Rilling studies, utilizing naive subjects, a separate-groups design, an extended baseline determination period, and extended discrimination training. The present study also included a comparison of a "blackout" procedure, here defined as the darkening of both the response key and the experimental chamber (referred to as "timeout" by both Reynolds and Friedman and Guttman), with a "timeout" procedure, here defined as simply the darkening of the response key alone. In addition, one group was trained with a stimulus associated with extinction to assure that behavioral contrast, as normally demonstrated, would occur with the procedures and equipment used in the present study.

METHOD

Subjects

Six experimentally naive, adult White Carneaux pigeons were maintained at 80% of their free-feeding weights.

Apparatus

A standard two-key Grason-Stadler operant chamber, with associated scheduling and recording equipment located in an adjacent room, was used. Only the left key was used in this study, with the right key taped over. A force of 0.15 N was required to operate the key. White noise was present at all times in the experimental chamber.

Preliminary training consisted of one day of magazine training plus key-peck shaping, followed by two days of training where each response was reinforced, for a total of 30 reinforcements each day. This was followed by two daily half-hour sessions of training on a variable-interval 30-sec (VI 30-sec) schedule of reinforcement, for a total of 60 reinforcements each day.

Following this pretraining phase, training consisted of daily 1-hr sessions on a VI 60-sec schedule of reinforcement, and continued for 36 sessions. The green keylight was present at all times during preliminary training and VI 60-sec training.

Discrimination training was begun on the thirty seventh day. Ten 3-min presentations of

the positive stimulus (the green keylight) were alternated in an irregular order with one of three different negative stimulus conditions, each of which was also of 3-min duration. For the timeout group (Birds 65 and 66) only the keylight was turned off. For the blackout group (Birds 69 and 70), both the keylight and the houselight were turned off. For the S^A group (Birds 67 and 68) a red keylight served as the negative stimulus. Responding in the presence of the positive stimulus was reinforced on the same VI 60-sec schedule as before. The reinforcement tape did not operate during the negative stimulus presentations. Reinforcers scheduled, but not obtained during the positive stimulus, were held over to the next presentation of the positive stimulus.

After 25 sessions on the original discrimination procedure, Birds 65, 67, and 68 were shifted to the blackout procedure, and Birds 66, 69, and 70 were exposed to the red stimulus (S^A) during the negative condition.

RESULTS

The results, beginning with the first day of VI 60-sec training, are presented in Figure 1, which plots response rate as a function of sessions for the individual animals in the three groups of the experiment. The upper curve for each animal represents the VI response rate. The lower curves represent responding during the various negative conditions. The specific condition in effect is represented by the following abbreviations: TO = timeout; BO = blackout; and S^A = S-delta (the red keylight). The short horizontal line in the left-hand portion of each bird's data represents the mean rate of responding over the last 10 days of VI training.

An interesting feature of the data is the large number of VI 60-sec sessions required to achieve stable baseline rates of responding. Had only 10 or 15 sessions been conducted before introducing the negative condition, it would have been impossible to determine whether an increase in responding during discrimination training was due to behavioral contrast, or merely due to continued increases in response rate on the VI schedule itself.

The top row of Figure 1 presents the results for the two birds in the timeout group. When discrimination training was begun, one bird (#65) tended to respond to the dark key,

whereas #66 never responded during this negative condition. Both birds however, exhibited behavioral contrast, as evidenced by the increase in responding during the positive stimulus.

The data for the two birds in the blackout group (#69, 70) are presented in the lower right-hand portion of Figure 1. Neither bird responded during the negative condition; again, however, both birds exhibited substantial contrast. The lower left-hand portion of Figure 1 contains the results for the two birds (#67, 68) trained on the green (positive)-red (negative) discrimination. Both birds responded in S^A , and as would be expected, both exhibited behavioral contrast.

Thus, for all birds, behavioral contrast occurred regardless of the nature of the negative condition, and most importantly, regardless of whether responding occurred in the negative condition.

In addition to presenting the results for the three original groups, the data for the individual animals in Figure 1 have been arranged in terms of whether or not responding occurred in the presence of the original negative condition. This results in two groups of three birds each, and is represented by the left-hand and right-hand columns in the figure. When the data are viewed in this respect, another interesting feature becomes apparent: those birds responding during the original negative condition exhibit "peak contrast" (Bloomfield, 1966) where the rate of responding in the presence of the positive stimulus rapidly decreases back towards the baseline level. However, for the birds that never responded in the negative condition, behavioral contrast is maintained over the entire 25 sessions.

In an attempt to compare the magnitude of the contrast effect for those animals that responded during the negative condition (Birds 65, 67, 68), and those that did not (Birds 66, 69, 70), the peak rate of response was determined. This was taken as the highest daily response rate during the first ten days of discrimination training. This peak rate was then expressed as the percentage increase in responding it represented over the mean of the last 10 days of VI 60-sec training. For the three birds that exhibited responding during the negative condition, the mean percentage increase in responding above baseline was 44.1%. For the three birds that did not re-

spond during the negative condition, this increase was 33.9%.

When the three birds that responded during the original negative condition were shifted to the blackout condition, little or no change in responding occurred in the presence of the positive stimulus. For the two birds in the blackout group that were shifted to the S^A condition, responding occurred in the presence of the negative stimulus, as did the peak contrast effect in the positive stimulus. For the one timeout bird that was shifted to the S^A condition, little non-reinforced responding occurred, accompanied by a slight increase in re-

sponse rate in the presence of the positive stimulus.

DISCUSSION

Considering the objections raised in the introduction to the baseline training procedures used in previous studies on behavioral contrast, it is of major significance to note that 20 to 25 days of training were needed for most animals to achieve stable response rates on the present variable-interval schedule. If one were to use only the first 10 or 15 days to measure VI baseline rates of responding, or to calculate

Fig. 1. Responses per minute as a function of sessions for the individual animals in the three groups of the experiment. The upper curve for each animal represents the variable-interval (VI) response rate. The lower curves represent responding during the various negative conditions. The specific condition in effect is represented by the following abbreviations: TO = timeout; BO = blackout; S^A = S-delta. The short horizontal line in the left-hand portion of each bird's data represents the mean rate of responding over the last 10 days of VI training.

a single mean baseline rate of response, and then compare the rates of responding on the next 10 to 15 sessions with such baselines (as many previous studies have done), one might be tempted to conclude that behavioral contrast had occurred, when in fact, such changes could easily be due to changes in the baseline rate of response alone. Thus, the present results strongly suggest that to have accurate and unequivocal measures of behavioral contrast, future studies should plan on considerably more baseline training than has previously been the case.

A major finding of the present study is that all animals, regardless of the nature of the negative condition, showed substantial increases in rate of responding in the positive stimulus. It is clear that timeout and blackout are both effective determinants of behavioral contrast. This demonstrates that behavioral contrast can be obtained whether or not responding occurs in the negative condition. Thus, a reduction in the rate of responding in one of two alternating stimuli is not a necessary condition for the occurrence of behavioral contrast, and thus, the present results provide an important exception to Terrace's (1968) postulation of two distinct types of discrimination learning.

In a recent article, Terrace (1972) appears to have amended his 1968 position somewhat. This was prompted by a study by Wilkie (1972), which showed that behavioral contrast did not occur despite a reduction in response rate in one of two alternating stimuli caused by the use of a variable-time schedule of non-contingent reinforcement. The present study further qualifies Terrace's original position by showing that behavioral contrast can occur despite no reduction in response rate in one of two alternating stimuli.

Terrace's amended proposal essentially states that an active withholding or suppression of responding in one of two alternating stimuli, rather than the mere reduction of responding, is necessary for contrast to occur in the other stimulus. The suppression of responding can be due to any one of several factors, such as the use of aversive consequences like electric shock, the use of less-preferred schedules of reinforcement such as DRL schedules, or to the inhibitory consequences of non-reinforced responding. In fact, Terrace makes a cogent argument for the fact

that all of the above situations are aversive, citing the equivalent effects of electric shock and non-reinforced responding in producing the peak shift found by Grusec (1968), the finding that a stimulus associated with non-reinforced responding is aversive by virtue of the fact that its termination will serve to maintain escape behavior (Terrace, 1971), the finding that pigeons will prefer a VI schedule to a DRL schedule (Fantino, 1968), and the finding that a stimulus associated with a DRL schedule acquires inhibitory stimulus control (Weissman, 1969). Terrace goes on to argue that the presence or development of inhibitory stimulus control is the single underlying characteristic of all those situations in which behavioral contrast occurs. The present results suggest that it might be more parsimonious to consider the relative aversiveness of one of two alternating stimuli as the primary determinant of behavioral contrast (as suggested by Premack, 1969), with inhibitory stimulus control being a by-product of such aversive situations. Although the suppression of responding by timeout or blackout might be considered inhibitory, it would appear to be methodologically impossible to demonstrate inhibitory stimulus control by such stimuli or events. However, it has been amply demonstrated that timeout or blackout is an aversive event (Leitenberg, 1965; Carlson, 1972), and it would seem that only by appealing to the known aversive properties of such events can Terrace integrate the present findings into his latest theoretical formulation.

An interesting finding of the present study is that those animals that responded during the negative condition exhibited what has been termed "peak contrast" (Bloomfield, 1966), where responding in the presence of the positive stimulus returns toward the baseline level after reaching an initially high (peak) rate. However, peak contrast has previously been associated with the use of a "correction" procedure in the negative condition, where any responding towards the end of the interval postpones the onset of the next positive interval. Such a correction procedure was not used in the present study, and it is thus instructive to consider what aspects of the current study have consequences similar to that of a correction procedure. It should be noted that a correction procedure basically results in a more rapid elimination of non-

reinforced responding than if no such contingency is used. Rather than serving to "punish" responses during the negative condition, as Bloomfield (1966) suggested, the correction procedure may simply represent a form of massed extinction, as responses primarily serve to prolong the duration of the negative condition. Although no correction procedure was used, the present data do reveal a fairly rapid reduction of non-reinforced responding, as well as initially low rates of responding during the negative condition. These generally low rates of response, and rapid decreases in rates of responding over the first few sessions, may have been responsible for the peak contrast phenomenon found here.

Several facets of this study may have been important in producing such minimal levels of non-reinforced responding: (1) the use of a single stimulus baseline rather than a multiple schedule baseline. In the case of a multiple schedule baseline, responding is explicitly reinforced in the presence of the stimulus that later becomes associated with non-reinforcement. This should result in much greater resistance to extinction than in the single stimulus situation, where responding in the negative stimulus is presumably just a function of the amount of generalized responding carried over from the positive stimulus. (2) The use of a comparatively "easy" discrimination. It has been well documented that the easier a stimulus discrimination, that is, one in which the discriminative stimuli are physically well separated, the fewer the number of non-reinforced responses (Frick, 1948; Pierrel, Sherman, Blue, and Hegge, 1970). The use of ordinary red and green lamps, without careful control over brightness and wavelength, as well as the use of timeout in the case of Bird 65, undoubtedly represent quite disparate stimuli, given what is known about the pigeon's spectral sensitivity. (3) The use of an extended (36-hr) period of variable-interval baseline training. This may have resulted in the occurrence of an "over-learning-extinction effect" (North and Stimmel, 1960; Ison, 1962; Traupmann and Porter, 1968), where resistance to extinction is at times an inverse function of the amount of reinforced training, or number of reinforcements. Thus, it is reasonable to suggest that the use of a correction procedure in and of itself is not a necessary condition for the occurrence of peak contrast, but that any condition or com-

bination of conditions that facilitates the elimination of non-reinforced responding might be sufficient for the occurrence of this phenomenon.

The finding that animals that respond during the negative condition exhibit peak contrast, while those animals that never respond during the negative condition demonstrate maintained or sustained contrast, might be related to differences in the relative aversiveness of the negative conditions. Although little is known about both the behavioral and physiological consequences of blackout, other than that it appears to be aversive, it seems reasonable to suggest that this aversiveness stems from the unconditioned suppression of behavior that it elicits, rather than there being something inherently aversive about the dark for the pigeon. Given the assumption that the effects of blackout are largely unconditioned in nature, then one would expect such effects to be relatively constant with repeated presentations over time. In this way, it is possible to view the maintained contrast exhibited by the animals in the blackout group as a consequence of the relatively constant aversiveness of the blackout condition.

For the animals in the S^A group, the aversiveness presumably arises from the frustrative and emotional consequences of non-reinforced responding (see Terrace, 1972). Since non-reinforced responding progressively decreases, we should expect the aversiveness associated with such situations similarly to decrease. That the aversiveness of a stimulus associated with extinction does in fact decrease progressively during discrimination training has been shown by both Rilling, Askew, Ahlskog, and Kramer (1969), and Terrace (1971). Thus, to the extent that behavioral contrast is a function of the aversiveness of the negative condition, we would expect contrast to decrease progressively during training, as it does for the animals in the S^A group. Furthermore, the above arguments suggest that the lower the amount of non-reinforced responding, the sooner the contrast effect is likely to disappear.

For animals in the timeout group, where only the keylight is turned off, both peak contrast and maintained contrast are obtained, depending on whether or not responses are made in the negative condition. This suggests

that the effects of timeout, as defined here, are subject to individual differences between birds. Furthermore, it suggests that there is nothing intrinsically inhibitory or aversive about a dark or blank key. Rather, the effects of timeout will be a function of whether or not responding occurs in its presence. If responding does occur, a timeout will function as an S^A ; if no responding occurs, it will function as a blackout.

Implicit in the above analysis is the notion that the aversiveness of a blackout will be of greater duration, or be of greater permanence, than the aversiveness of an S^A . This is not to be confused with differences in the magnitude or degree of aversiveness of the two events. Both Rilling, *et al.*, (1969) and Terrace (1971) have shown that pigeons will prefer a blackout condition to a stimulus associated with non-reinforcement, indicating that an S^A is more aversive than a blackout, particularly during the early sessions of discrimination training. In the present study, the magnitude of the peak rate of response in the presence of the positive stimulus was chosen as an index of the relative aversiveness of the negative conditions. As mentioned in the Results section, the mean percentage increase above baseline for the animals that respond during the negative condition was 44.1%, considerably greater than the 33.9% increase above baseline exhibited by the animals that did not respond during the negative condition. Thus, although the permanence of the aversiveness of blackout may be greater than that of S^A , the magnitude of the aversiveness of S^A appears to be greater than that of blackout.

By emphasizing the notion that the aversiveness of an S^A or a blackout is primarily a function of its effect on responding, rather than of anything intrinsic to such stimuli or events, it is possible to offer an explanation for the results obtained during the third phase of the study. As shown in Figure 1, the three animals that had responded during the negative condition (Birds 65, 67, 68) were switched to the blackout condition, while the animals that had not responded during this condition (Birds 66, 69, 70) were exposed to the S^A (red keylight) condition. Although the data are somewhat variable for the three animals switched to the S^A condition, all animals evidence responding during this condition, presumably engendered by generalization from

the green to the red stimulus, and all animals show some form of rate increase in the presence of the positive stimulus. This additional increase in behavioral contrast may be due to the increased aversiveness afforded by the S^A as compared to blackout, and again, is presumably due to the frustrative and emotional consequences of non-reinforced responding. Of more interest is the finding that those animals switched from the S^A condition to the blackout condition demonstrated virtually no change in rate of responding in the presence of the positive stimulus. This can be accounted for in one of two ways: first, if as suggested earlier, blackout is less aversive than S^A , then this change represents no increase in aversiveness during the negative condition, and hence there should be no increase in rate in the positive stimulus. One might argue that there should actually be a decrease in rate in the presence of the positive stimulus if one is decreasing the aversiveness of the negative condition. However, note that rates of response in the positive condition have already returned to their baseline levels, indicating that the condition associated with non-reinforcement is no longer aversive, as shown by Rilling, *et al.*, (1969) and Terrace (1971). Thus, the second, more likely explanation would argue that although responding is still inhibited or extinguished during the S^A condition, the aversiveness associated with this condition has disappeared by the end of the second phase of the study. Then, the introduction of the blackout condition would have no effect, as no responding remains to be inhibited or suppressed in its presence. Thus, for these animals that have already learned not to respond, there is nothing aversive about the blackout, and thus there is no increase in responding in the presence of the positive stimulus.

There are several important implications of the finding that both timeout and blackout produce behavioral contrast when alternated with a stimulus associated with positive reinforcement. Many investigators have tended to use either timeout or blackout to separate stimulus presentations, particularly in those discrimination situations that involve testing for stimulus generalization, and in those situations where one wishes to minimize the adventitious conditioned reinforcement of responding in the negative condition by the on-

set of the positive stimulus. Some behavioral contrast would probably occur in such situations due to the use of timeout or blackout alone, and if behavioral contrast were to be one of the phenomena of interest in such studies, the results would be confounded by the additional contrast resulting from the presence of timeout or blackout.

In a related fashion, a few studies have used blackout or timeout periods as a way of producing spaced *versus* massed trials in a free-operant situation. Both Mackintosh, Little, and Lord (1972) using timeout, and Taus and Hearst (1970) using blackouts, found higher variable-interval response rates with spaced as opposed to massed trials. Rather than being due to the effects of spaced trials *per se*, the results of both these studies are easily accounted for by the contrast-producing properties of timeout and blackout as demonstrated in the present study.

Another caution concerns the use of a "blank" key as a supposedly neutral condition. Terrace (1972) suggested using a blank key in the presence of which noncontingent negative reinforcers would be presented, to see if increases in response rate would be evidenced in an alternated positive stimulus. Note that the blank key, a timeout, should result in behavioral contrast occurring in the presence of the positive stimulus regardless of what other conditions are scheduled in its presence.

Finally, it may have occurred to some readers that the original errorless training procedure described by Terrace (1963) made use of timeouts during the initial phase of training. Terrace began with a completely dark key, and gradually increased the duration of the timeout before increasing the intensity of the green keylight. According to the present results, the use of a dark key should have resulted in the occurrence of behavioral contrast. The fact that Terrace's errorless procedure results in the absence of behavioral contrast may indicate that there is something about the early introduction of discrimination training with little or no baseline training (as suggested by Yarczower, *et al.*, 1966), or the progressive introduction of the negative stimulus, that precludes or attenuates the occurrence of behavioral contrast. These possibilities are now being studied by the present writer.

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Received 15 January 1971.

(Final Acceptance 14 December 1972.)