The differential effects of punishment and extinction on behavioral contrast

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Two white rats were run on a MULT VI 30 VI 30 VI 30 schedule of reinforcement until they achieved a steady rate of responding from session to session and from component to component. They were then run on a MULT PUN-EXT VI 30 EXT VI 30 schedule of reinforcement. Higher rates of responding were observed in the reinforcement component following PUN-EXT than in the reinforcement component following EXT. The results were discussed in relation to present theories of behavioral contrast and in relation to the aversive qualities of the suppression stimuli and the conditioned reinforcing properties of barpressing.

During the successive formation of a discrimination between one stimulus associated with reinforcement and one stimulus associated with extinction, the rate of responding during the presence of the reinforcement stimulus typically rises, while the rate of responding during the stimulus associated with nonreinforcement typically decreases. This phenomenon, termed behavioral contrast, is most reliably produced by introducing a stimulus correlated with extinction (Reynolds, 1961a) or with time-out (Reynolds, 1961b). It may also be produced by systematically manipulating the value of the fixed ratio (Reynolds, 1961c) or the value of the variable interval (Reynolds, 1963). But if the schedule in the varied component is changed from VI to DRO, so that reinforcement occurs fairly frequently despite the absence of responding, no contrast effect is observed (Reynolds, 1961a).

This has led Reynolds to postulate that contrast effects occur when the relative frequency of reinforcement correlated with the constant component increases as the absolute frequency of reinforcement correlated with the variable component decreases. Thus, the absolute rate of responding during the constant component increases, even though the absolute rate of reinforcement does not.

But not all contrast effects depend on changes in the rate of reinforcement. Brethower & Reynolds (1962) produced contrast by introducing punishment in the varied component while holding the rate of reinforcement constant. Responding was suppressed during the varied component, but increased during the constant component as a function of

the intensity of punishment in the varied component. But the rate of reinforcement during the varied component was not kept constant. Terrace (1968) suppressed response rate by shock while maintaining constant reinforcement frequency across components, reliably producing positive contrast effects.

This present study is an attempt to study the functional equivalence of punishment and extinction in producing contrast and to throw light on the reinforcement frequency (Reynolds, 1961d) vs response suppression (Terrace, 1968) hypotheses accounting for contrast.

SUBJECTS

Two albino male rats of the Sprague-Dawley strain (Simonson Labs, Gilroy) were maintained and run at $80\% \pm 4\%$ of their free-feeding weights. Neither had been previously exposed to conditioning procedures.

APPARATUS

The response chamber was equipped with a magazine for controlled presentation of food pellets (the reinforcer), a response lever operated by an effective force of 15 g, and a white light and speaker for the presentation of various discriminative stimuli. Standard electromechanical programming and cumulative recording equipment were used.

The punisher was electric shock, which was delivered through grids on the floor of the experimental chamber via a Grason-Stadler shock generator and grid scrambler. The rats were shocked for each barpress for approximately 1 sec, at a shock intensity of 1 mA. The shock intensity was gradually built up to prevent complete cessation of responding.

PROCEDURE

Phase I

A daily experimental session consisted of six cycles of a three-component multiple schedule of reinforcement. Each cycle consisted of 3 min of illumination with white light,

followed by 3 min of no illumination, followed by 3 min of no illumination with white noise at an intensity of 83 dB. Barpressing was reinforced with one food pellet on a variable-interval (VI) schedule of 30 sec during all three components of the multiple schedule (MULT VI 30 VI 30 VI 30). The rats were run on Phase I until they achieved a steady rate of responding from session to session and from component to component.

Phase II

Each daily experimental session consisted of five cycles of a four-component multiple schedule. Each cycle consisted of 3 min of illumination with white light, during which every barpress was punished with electric shock, 3 min of no illumination with white noise (83 dB), during which reinforcement was available on a VI 30 schedule of reinforcement, 3 min of no illumination with no white noise, during which no reinforcement was available and no punishment was delivered for barpressing, and 3 min of no illumination with white noise, during which reinforcement was available on a VI 30 schedule of reinforcement (MULT PUN-EXT VI 30 EXT VI 30). The two reinforcement conditions were equivalent with regard to S^d and rate of reinforcement.

RESULTS

Figure 1 shows first the comparative effects of shock and extinction on the rate of punished and unreinforced responding. Session 0 is the average rate of responding for the last three sessions before Phase II. Sessions 1-5 are successive sessions. During this phase, every response in S_1 was punished and no reinforcements were delivered, and no responses during S_3 were reinforced. This result is in agreement with the findings of Holz & Azrin (1963) on the comparative effects of punishment and extinction on responding. Punishment immediately and effectively suppresses responding, whereas responding during extinction decreases more slowly and may equal or surpass responding during reinforcement in the sessions immediately following its introduction.

The changes observed in the rate of unpunished and reinforced responding after each cycle are of primary interest here. Figure 1 also shows the rate of responding during S_2 (VI 30 following PUN-EXT) and S_4 (VI 30 following EXT). Although the same schedule of reinforcement was used for Phases I and II, the rate of responding differentially increased during S_2 and S_4 of Phase II. Thus, besides the usual contrast effects, a differential contrast effect was observed in the two

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Fig. 1. Rates of responding (barpresses/minute) during all components of Phase II: MULT PUN-EXT VI30 EXT VI30. Session 0 represents the average rate of responding for the last three sessions of Phase I.

reinforcement cycles of Phase II, the higher rates of responding following the PUN-EXT cycle. Except for Session 1 for Rat 2, where the PUN-EXT produced negative induction in the cycle following it, the differences are consistent.

DISCUSSION

The results of this study, combined with other evidence, seem to show that not all contrast effects can be accounted for by Reynolds's relative reinforcement frequency hypothesis (Reynolds, 1961d). Behavioral contrast was reliably produced following the PUN-EXT condition and the EXT condition. But in the reinforcement component following PUN-EXT, consistently greater contrast was produced than in the reinforcement component following EXT. Brethower & Reynolds (1962) found that behavioral contrast was reliably produced both by changes in the rate of reinforcement and by punishment and that changes in the magnitude of punishment produced greater contrast effects. Terrace (1963) has demonstrated that the occurrence of contrast is dependent on unreinforced responding during extinction, and not necessarily on the relative frequency of reinforcement.

The rate of reinforced responding is affected both by the relative rate of reinforcement during S+ and the presence of punishment during S-. How do we account for behavioral contrast when the rate of reinforcement is not manipulated and for the differential contrast found here when both relative rate of reinforcement and punishment were manipulated? Not easily within the present theoretical framework.

Reynolds's relative reinforcement frequency, when freed of the positive reinforcement constraint, might account for these results. It might be inferred that punishment, as a negative reinforcer, adds to the relative positive reinforcement effect of the subsequent component, thus accounting for the differential response rates in the two reinforcement components. It might also be possible to account for these results without recourse to discrimination learning. Terrace (1966) has suggested that contrast may reflect the aversiveness of response suppression. Scull, Davies, & Amsel (1970) found that significant contrast effects were produced only in components immediately following a frustrating nonreward condition in both multiple and mixed schedules. Reference to Fig. 1 would show that shock produces immediately and consistently a lower rate of responding than extinction. It might be inferred from these data that shock plus extinction is more aversive than extinction alone. The resulting differences in the rate of responding following the punishment and extinction condition might reflect the differential emotional-facilitatory aftereffects of punishment and extinction and extinction alone.

But contrast may also appear as a reduction of rate in the constant component when the rate increases in the varied component. In Reynolds's (1963) Experiment I, increasing the frequency of reinforcement from 13 to 35 per hour in the presence of the green key produced rate increases in green and rate decreases on an alternate red key, which was correlated with a constant 20

reinforcements per hour. It is not clear, in this case, how such decreases can be accounted for by the aversive qualities of the constant component. Nor is it clear how emotional reactions can be experimentally manipulated for study.

A more economical and comprehensive explanation of behavioral contrast can be developed if Reynolds's relative rate of reinforcement frequency hypothesis is expanded to include secondary reinforcement. Barpressing takes on the qualities of a secondary reinforcer because of its direct association with primary reinforcement. Punishment, extinction, schedule change, and time-out may all be regarded as methods of manipulating the deprivation level of the S from this secondary reinforcement. The more immediately and directly a stimulus suppresses responding, the more deprived the S becomes. Reference to Fig. 1 indicates that PUN-EXT leads to greater deprivation than EXT, as the response rates during PUN-EXT are uniformly lower. This greater deprivation from secondary reinforcement produces greater response rates in the reinforcement conditions following. Brethower & Reynolds's (1962) finding that greater contrast was produced by increasing the magnitude of the punisher would corroborate this explanation.

This explanation of contrast would also subsume Terrace's hypothesis based on the aversive qualities of stimuli associated with decreases in the rate of responding. In the case of Reynolds's (1963) Experiment I, barpressing during green has greater secondary reinforcing value because it is associated with a higher rate of reinforcement. Kelleher and Gollub (1962) conclude from a review of the literature that the evidence indicates that the conditioned reinforcing effectiveness of a stimulus is directly related to the frequency of primary reinforcement occurring in its presence. This explanation would also account for the differential contrast effects found when reinforcement and extinction components are presented in random order (Terrace, 1966; Scull, Davies, & Amsel, 1970). Response rates are higher in the reinforcement condition immediately following extinction than in a reinforcement condition immediately following a reinforcement component. Nevin and Shettleworth (1966) have shown that initial response rates in a reinforcement component following an extinction component are inflated. The response rate levels out as the component proceeds. The inflated rates of responding are termed transient contrast effects. But whether

or not these transient effects occur, sustained contrast effects are maintained, and these sustained contrast effects are not easily explained by traditional theories. This explanation of contrast based on the value of the secondary reinforcer relative to the deprivation level of the S or its correlation with reinforcement is advantageous, since it lends itself to experimental manipulation. But it remains to be tested, by using standard techniques to demonstrate the differential strength of secondary reinforcers.

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