An Analysis of Behavioral Contrast in a Concurrent Schedule Using Qualitatively Different Reinforcers

Lodge
AN ANALYSIS
OF BEHAVIORAL CONTRAST
IN A CONCURRENT SCHEDULE USING
QUALITATIVELY DIFFERENT REINFORCERS

by

Richard J. Lodge

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Faculty of The Graduate College
in partial fulfillment
of the
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Richard J. Lodge
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INTRODUCTION

Concurrent operants are defined as "two or more responses, of different topography or at least with respect to locus, capable of being executed with little or no interference at the same time or in rapid alternation, under the control of separate programming devices" (Ferster and Skinner, 1957, p. 724). There are basically two methods that concurrent schedules can be arranged. In one method, each operant and the associated schedule of reinforcement is assigned to individual manipulanda. By the second method, all schedules of reinforcement are assigned to the same manipulanda and there are different exteroceptive stimuli to indicate which schedule is in effect. Alternation from one schedule of reinforcement to another schedule is made by responding on a second manipulanda (changeover key). In both methods, each schedule of reinforcement is associated with its own exteroceptive stimuli and each schedule functions continuously (Stubbs and Pliskoff, 1969).

Response rates for each operant under concurrent situations are different than if each operant is studied in isolation (Catania, 1966). When we look at complex interactions, two or more operants, the response rate varies not only with the schedule of reinforcement for
that operant, but also with the schedule of reinforcement for the other operant(s) (Catania, 1963).

The response rate in one ply of a concurrent schedule can be changed by a schedule manipulation in the other ply. As the reinforcements per hour for one ply of a concurrent schedule increases, given the reinforcement schedule for the other ply remains constant, the rate of responding in the changed ply increases. There is also a simultaneous decrease in responding during the other constant ply (Catania, 1966). Reynolds (1961c) concluded that the relative rate of responding in the constant ply, as a function of the relative reinforcement rate in that ply, approximated a straight line.

These changes or interactions in response rates that occur as a function of schedule manipulations can be referred to as either induction or contrast. Behavioral contrast as described by Reynolds (1961a) refers to a change in the rate of responding in one ply in a direction away from the response rate prevailing in the other procedurally manipulated ply. When there is an increase in the rate of responding in the constant ply in a direction away from the rate of responding in the altered component, the interaction is termed positive contrast. Negative contrast refers to a decrease in response rate in the constant component.

Contrast has been experimentally reported following a variety of schedule manipulations. Most studies
reporting contrast have utilized a multiple schedule of reinforcement design. A number of experiments have reported an increase in the response rate in the unchanged component by altering the absolute frequency of reinforcement in the procedurally manipulated component (Reynolds, 1961a, 1961b, 1961c, 1963; Reynolds and Catania, 1961 and Nevin and Shettleworth, 1966). Brethower and Reynolds (1962), reported a positive contrast effect using a mult VI 3 VI 3 reinforcement schedule with each response punished in only one ply.

All the previous studies cited utilized pigeons as subjects. There are few reported studies demonstrating the occurrence of contrast in species other than pigeons. In a study by Pear and Wilkie (1971), rats were initially trained on a VI 30-sec schedule of reinforcement. When a mult VI 30-sec EXT schedule of reinforcement was introduced, there was an increase in responding during the mult VI 30-sec ply above the initial VI 30-sec baseline level of responding (positive contrast).

While many different reinforcers and response topographies have been studied, the number of experiments using qualitatively different reinforcers to assess behavioral interactions are few in number and the results are not all in agreement with results utilizing similar reinforcers. Stein (cited in Olds, 1962), used electrical stimulation of two different brain sites as dissimilar reinforcers. The separate response rates maintained on
both manipulanda equaled the response rate when only one manipulandum was available. The addition of a second but different reinforcer did not result in a decrease (negative contrast) in the response rate that was maintained by a single reinforcer in isolation. This independence of response rates maintained by different reinforcers was also reported by Catania (1966). In this experiment, rates of lever presses were reinforced on both a FR 100 (food reinforcement) schedule and a modified Sidman avoidance schedule (response shock and shock-shock intervals equal to 30 sec). The schedules were programmed either concurrently or separately. The removal of one of the reinforcement schedules did not systematically produce interactions in the response rates maintained by the other schedule.

Whelan (unpublished thesis) reported results using pellets and sucrose water as different reinforcers. After achieving a stable response rate on mult VI 1 VI 1, the lever that was functional in producing pellets was switched to EXT for all three subjects. The response rate in the sucrose component increased and stabilized at a level above the average rate of response that were maintained in the baseline condition. Reinstatement of mult VI 1 VI 1 conditions re-established rates similar to those during baseline.

The results of a study by Beninger (1972) indicated that qualitatively different reinforcing stimuli in the
two components of a multiple schedule produced contrast. Beninger used a mult VI 30-sec (food) VR 3.3" schedule of electrical stimulation of the brain (ESB). When the schedules of reinforcement was changed to a mult VI 30 EXT, a positive contrast effect was obtained.

As previously cited, Catania (1966) did not obtain interactions between concurrently programmed schedules with qualitatively different reinforcers. He suggested that when current schedules of reinforcement are presented, interactions may depend on the similarities of reinforcers. In a study by Hollard and Davidson (1971), pigeons were studied using a two-key concurrent VI with food reinforcement on one key and ectostriated brain stimulation as the reinforcer on the other key. Behavioral contrast was obtained by establishing baseline on concurrent VI 1 VI 1 schedule of reinforcement. When one ply (food) was changed to VI 10', there was a concomitant increase in the response rate to the unchanged VI 1 ply (brain stimulation). This schedule manipulation utilizing different reinforcers with a concurrent schedule of reinforcement was in disagreement with the hypothesis proposed by Catania (1966).

The present study was designed to determine if behavioral interactions occur with qualitatively different appetitive reinforcers maintained by a concurrent schedule of reinforcement. Reinforcement parameters were chosen to encompass a wide range of schedule manipulations which
have been shown to be sensitive in experiments using a single reinforcer. In addition, the schedule manipulations will incorporate two reinforcers (pellets and sucrose water) and subjects (rats) that have been used in single reinforcer designed experiments to further facilitate a comparison of this study with previous research.
METHOD

Subjects

Four adult Sprague-Dawley male albino rats, maintained at 80% of their free-feeding weights, served as subjects. None of the subjects were water deprived. All four rats had previously been trained on a multiple schedule of reinforcement which utilized food pellet and sucrose water reinforcement. None had prior concurrent schedule training.

Apparatus

The test apparatus was a specially constructed 49.6 wide x 31.9 high x 30.1 cm deep two lever chamber equipped with both a pellet feeder and liquid feeder. The centers of the two levers were 38.9 centimeters apart and 3.54 centimeters above the chamber floor. Both reinforcement dispensers were located 15.9 centimeters from their respective lever and 5.3 centimeters on either side of the center of the control panel. Directly above each lever were three cue lights. Appropriate electronic and electromechanical equipment was used to program the various schedules and record the behavior.
Procedure

The four subjects had a history of reinforcement to press lever A (right lever) which was reinforced by 45 mg Noyes pellets, and also to press lever B (left lever) which was reinforced by 3.5 second access to .1 cc of a 20% sucrose solution. All subjects had been trained on a multiple schedule of reinforcement. In this experiment, a concurrent reinforcement schedule was implemented beginning with a concurrent VI 30 VI 30" schedule of reinforcement. The reinforcement schedule was changed until responding on both levers was maintained by a concurrent variable interval 1 minute (VI 1 VI 1) schedule of reinforcement. All sessions terminated after 100 total reinforcements had been delivered and maintenance food was given immediately after each session.

Reinforcement for both levers was programmed by independent variable interval timers. Responses on lever A were physically incompatible with responses on lever B and a shift from one lever to the other initiated a 1.8-sec changeover delay (cod). If a reinforcement on lever A was scheduled while the subject was emitting responses on lever B, a shift of responding to lever A would not be reinforced until a response occurred after the 1.8-sec cod duration had elapsed.

When response rates stabilized, the reinforcement schedule for one ply was systematically varied.
Stability was determined by visual inspection of the records. With two subjects (A1 and A2) pellets were scheduled during the varied ply; with the other two subjects (A3 and A4), sucrose was the reinforcer in the varied ply.

The successive experimental manipulations for each of the subjects is summarized in Table 1, column 1. Subjects A1, A2 and A3 were exposed to schedule manipulations that varied along ascending and descending series of schedule changes. Subject A4 was exposed to only an ascending series of schedule manipulations. Due to the many sessions required before stability of responding was obtained and a later sickness, subject A4 was exposed to only two schedule manipulations.
RESULTS

The mean number of responses (responses per minute) for all subjects was based upon the last five sessions under each condition and was computed for both the food pellet and sucrose plys. The figures in which the data are tabulated are discussed in detail later in this chapter. However, figures 1-4 show the mean number of responses for both the sucrose and pellet components as a function of the schedule programmed in the varied ply. Relative time spent in the constant component is also shown in figures 1-4. Absolute time spent in each component was derived from two running time meters. One running time meter started when the first response was registered on lever A and terminated when a response was made on lever B. A subsequent shift to lever A restarted the running time meter and these times were cumulative during the session. The other running time meter ran for the total session and was terminated after 100 reinforcers were delivered. Relative time was calculated by dividing the total time spent in the constant plys by total session time x 100.

Decreasing reinforcement frequency in one ply decreased the absolute reinforcement rate in that ply and increased the relative frequency of reinforcement.
in the constant ply decreased. Column 4 in Table 1 is shown because the Ss did not always match the relative number of reinforcers with theoretical reinforcement values. Table 1 also lists the changes in relative number of responses and relative time spent in the constant ply as a function of schedule manipulations. Relative number of response was calculated by dividing responses per session in the constant plys by total responses for both plys x 100.

Subject A1 (Figure 1) showed a slight increase in number of responses in the constant ply (VI 1) as the reinforcement rate in the varied ply was decreased with maximum responding in the constant ply when EXT was programmed in the varied ply. The relative number of responses (responses during the constant ply as compared to the total response rate per session) during baseline was 66%, during VI 4' the relative number of response rose to 78%. There was not a discernible difference between the response rate in the constant ply during VI 4' and EXT, although there was an increase in relative reinforcement from 81% to 100%. When comparing the second baseline condition, following VI 1 EXT, to the first baseline condition, there was a shift in responses per minute for each ply. During the first baseline condition, responses that were reinforced by sucrose (constant ply) were at a higher response rate than those responses reinforced by pellets. During the
TABLE 1

Subjects, conditions and number of sessions during the varied plys of a two concurrent schedule of reinforcement are depicted in the first three columns. The next three columns show the relative time spent in the constant ply, relative number of reinforcers in the constant ply, and the relative number of responses in the constant ply.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Variable Ply Schedule</th>
<th>Number of Sessions</th>
<th>Relative Time Spent in Constant Ply</th>
<th>Relative Number of Reinforcers in Constant Ply</th>
<th>Relative Number of Response in Constant Ply</th>
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<td>VI 1'(pellet)</td>
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</tr>
<tr>
<td></td>
<td>2'</td>
<td>80</td>
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<td></td>
<td>66</td>
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<td>73</td>
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<td></td>
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<td>77</td>
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<td>A3</td>
<td>VI 1'(liquid)</td>
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<td></td>
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<td>62%</td>
<td>73</td>
<td>65</td>
</tr>
<tr>
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<tr>
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<td>VI 1'(liquid)</td>
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<td></td>
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<tr>
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<td>39</td>
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<td></td>
<td>97</td>
<td>63</td>
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<td>78</td>
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</tbody>
</table>
FIGURE LEGEND

Figure 1: The figure depicts the average number of responses for the subject Al under each condition. The ordinate represents the mean number of responses for the last five sessions as a function of schedule manipulations during the varied condition as shown on the abscissa of a two component concurrent schedule. The range of responses were also derived during the last five sessions. The right ordinate depicts relative time spent in the constant component. The schedule of reinforcement during the constant component was always VI 1.
FIGURE 1

RESPONSES PER MINUTE

SCHEDULE DURING VARIABLE COMPONENT (REINFORCERS/HOUR)

RELATIVE TIME IN CONSTANT COMPONENT

VARIED COMPONENT (PELLET)

CONSTANT COMPONENT (SUCROSE)
second baseline condition, the number of responses during those plys that were reinforced by pellets were at a higher rate as compared to those responses reinforced by sucrose. Following the reinstatement of baseline conditions, there was one descending reinforcement schedule manipulation which resulted in a slight decrease in the mean number of responses during the constant ply. The mean response rate was 25 responses per minute during conc VI 1 VI 1 as compared to 21 responses per minute during conc VI 1 VI 30". Coupled with the drop in response rate, the relative time spent in the constant ply dropped from 66 to 53%.

Rat A2 (Figure 2) showed a systematic decrease in response rate in the constant ply as reinforcement frequency was increased in the varied ply. The number of responses maintained by sucrose and pellets were approximately equal, 48%, in the concurrent VI 1 VI 1 baseline condition. When the varied ply schedule was changed from VI 1 to VI 30" then to VI 15", the mean response rate in the constant ply went from 53 to 23 responses per minute. When the schedule was changed back to VI 30" then to VI 1', the number of responses rose to 35 then to 61 responses per minute. The response rate was lowest in the constant ply when the varied ply was VI 15". The relative time in the constant ply as compared to responses per minute approximately paralleled changes in trend as a function of
FIGURE LEGEND

Figure 2: The figure depicts the average number of responses for the subject A2 under each condition. The ordinate represents the mean number of responses for the last five sessions as a function of schedule manipulations during the varied condition as shown on the abscissa of a two component concurrent schedule. The range of responses were also derived during the last five sessions. The right ordinate depicts relative time spent in the constant component. The schedule of reinforcement during the constant component was always VI 1.
FIGURE 2

- **Square**: Relative time in constant component
- **Circle**: Varying component (pellet)
- **Triangle**: Constant component (sucrose)

Responses per minute vs. schedule during variable component (reinforcers/hour)
schedule manipulations except during extinction. There was a possible induction effect when extinction was programmed in the varied ply. The number of responses dropped from 61 responses per minute to a mean of 43 responses per minute. In all 76 sessions that A2 was run before stability of responding was obtained, there were only 10 session days where the response rate in the constant ply was above the mean rate that prevailed in the second VI 1 VI 1 condition. The number of responses for approximately 87% of the sessions in the VI 1 EXT condition were below the mean number of responses of the previous condition. During the third VI 1 VI 1 baseline condition, the number of responses during both plys were equal. When the varied ply schedule was changed to VI 2, there was a slight increase in the number of responses during the constant ply. The mean response rate increased from 48 to 55 responses per minute.

Subject A3 (Figure 3) showed a decrease in the number of responses when the reinforcement schedule during the varied ply was changed from VI 1 to VI 15". The mean response rate decreased from 19 to 9 responses per minute and the relative time spent in the constant ply went from 31 to 17%. During the next two manipulations, the varied ply reinforcement schedule was changed to VI 30" and then to VI 1 with no significant change in the mean response rate. The relative time
FIGURE LEGEND

Figure 3: The figure depicts the average number of responses for the subject A3 under each condition. The ordinate represents the mean number of responses for the last five sessions as a function of schedule manipulations during the varied condition as shown on the abscissa of a two component concurrent schedule. The range of responses were also derived during the last five sessions. The right ordinate depicts relative time spent in the constant component. The schedule of reinforcement during the constant component was always VI 1.
FIGURE 3

- □ RELATIVE TIME IN CONSTANT COMPONENT
- ○ VARED COMPONENT (SUCROSE)
- ◇ CONSTANT COMPONENT (PELLET)

RESPONSES PER MINUTE

RELATIVE TIME IN CONSTANT COMPONENT

SCHEDULE DURING VARIABLE COMPONENT (REINFORCERS / HOUR)
spent in the constant ply did change from 17% during VI 15 to 30% and to 38% during VI 30" and VI 1 respectively. During extinction, the prevailing response rate in the constant ply did not change when compared to the prior and subsequent VI 1 VI 1 manipulation. When the reinforcement schedule was changed to VI 1 to VI 2 to VI 3 to VI 4, there was a constant increase in the mean number of responses in the constant ply. The mean response rate rose from 13 responses per minute during the VI 1 schedule to 23 responses per minute during the VI 3 and VI 4 reinforcement schedule. The change in relative number of responses (Table 1) during VI 1 to VI 4 schedule manipulations increased from 29 to 69%. Relative time spent in the constant ply also rose from 40 to 73% when comparing these same schedule manipulations.

Rat A4 (Figure 4) was the only subject that was not exposed to both ascending and descending schedule manipulations. Stability was not obtained during baseline until after 129 sessions. Although the relative time spent in the constant ply was approximately 50% during the baseline condition, the response rate during the ply with pellets as the reinforcer was 93 responses per minute as compared to 60 responses per minute during the ply with sucrose as the reinforcer. When the reinforcement schedule was changed from VI 1 to VI 2 to VI 3 in the varied ply, the mean response rate in the ply
FIGURE LEGEND

Figure 4: The figure depicts the average number of responses for the subject A4 under each condition. The ordinate represents the mean number of responses for the last five sessions as a function of schedule manipulations during the varied condition as shown on the abscissa of a two component concurrent schedule. The range of responses were also derived during the last five sessions. The right ordinate depicts relative time spent in the constant component. The schedule of reinforcement during the constant component was always VI 1.
rose from 60 to 82 to 109 responses per minute. The relative time spent in the constant ply (Table 1) rose from 49 (VI 1) to 63% (VI 3), and the relative number of reinforcers increased from 50 to 76%.
DISCUSSION

The results of this study are consistent with previous findings reporting positive behavioral contrast which have used only one reinforcer. When the data were reviewed for individual subjects, both positive and negative contrast was obtained. The resultant data from the series of ascending schedule manipulations during the varied plys for subjects A3 and A4 (Figure 3 and 4) are examples of the occurrence of positive behavioral contrast. During the last three schedule manipulations for subject A3, the number of responses in the varied ply was above the response rate during the reinstated VI 1 VI 1 baseline condition. Subject A4 showed the most dramatic contrast effect. The number of responses in the constant ply approximated a straight line as the schedule of reinforcement was increased. Negative contrast was demonstrated during the first four manipulations for subject A2. As the schedule of reinforcement was increased above baseline values during the varied ply, the rate of responding during the constant ply correspondingly decreased. Subject A3 showed negative contrast during the first manipulation.

According to Catania (1963), both relative time and relative rate of responding typically match the
relative rate of reinforcement. This relationship is supported in the present study. There was a change in relative time spent in the constant ply (Table 1) and the relative number of responses systematically varied with the relative number of reinforcers. There was, however, not a systematic relationship between relative reinforcement and the rate of responding during the constant ply. For example, in all instances when EXT was scheduled in the varied ply, subjects A1, A2 and A3, there was not a concomitant increase in number of responses per minute (Figures 1, 2, and 3). In this study, there is greater support that contrast occurred with qualitatively different reinforcers for time allocation measures than for response allocation measures.

Catania (1966) reported the use of two qualitatively different reinforcers, for concurrent operants, did not conform with results when a single reinforcer was used to maintain both responses. The results of the present experiment indicate that this may not be the case. Other studies (Beninger, 1972 and Hollard and Davison, 1971) using reinforcers that were not both appetitive stimuli also reported behavioral contrast. The findings of these experiments would suggest that behaviors maintained by different reinforcers do interact.

The results of this study are not uniformly consistent with previous studies which have used only one
reinforcer. With subjects A1, A3 and A4, responses per minute during the concurrent VI 1 VI 1 baseline were not equal. The differences between the sucrose and pellet response rates can be partially accounted for by the fact that the reinforcers were not equated as to their effectiveness. Steinman (1968a, 1968b) has reported that different rates of responding prevail during sucrose and pellet plys when they are not equated for effectiveness.

The phenomenon of concurrent and multiple schedule interactions is not limited to situations involving a single reinforcer. This study, along with other research, indicates that interactions occur under a wide variety of circumstances when reinforcement frequencies are manipulated during one ply of multiple or concurrent schedules. In the present experiment, the two reinforcers were not equated as to their effectiveness. Further research is needed to determine whether qualitatively different but equated reinforcers would yield results that are similar to experiments utilizing single reinforcers.
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