A Single Session Design to Assess Schedule Interactions

Thomas J. Edwards

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A SINGLE SESSION DESIGN
TO ASSESS SCHEDULE INTERACTIONS

by

Thomas J. Edwards, Jr.

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
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Thomas J. Edwards, Jr.
EDWARDS, Jr., Thomas Joseph
A SINGLE SESSION DESIGN TO ASSESS SCHEDULE
INTERACTIONS.

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INTRODUCTION

Over the past twelve years the description and analysis of behavioral contrast has become an area of increasingly popular investigation. Behavioral contrast is one type of behavior interaction, that is, a change in behavior during one stimulus condition brought about by procedural changes implemented during another stimulus condition. If this change in behavior is one in which the rate of responding is in a direction away from the rate of responding brought about by the manipulation in the other stimulus condition, then it is called behavioral contrast (Reynolds, 1961a). Behavioral contrast can then be broken down into two more specific types of interactions: positive contrast defined as an increase in the rate of responding in the constant condition; negative contrast being the inverse, that is, a decrease in the rate of responding (Reynolds, 1961b).

Most of the free-operant research investigating behavioral contrast has employed two-ply multiple schedules. In such schedules the two plys and their correlated stimuli are each associated with an independent schedule of reinforcement. The plys are then presented in either an alternating or semi-random order. Reynolds (1961a) provided a classic design for the study of contrast effects when he
analyzed the response rate during the constant VI ply of a mult VI 3-min VI 3-min schedule when the schedule was shifted to mult VI 3-min EXT. If a between-session analysis is made and the mean rate of responding in the constant ply is averaged over sessions and the rate is found to change in a direction away from the rate shown in the other ply, then this change describes a sustained contrast effect. If a within-session analysis is made there are two ways of assessing contrast effects. In a within-component analysis, if magnitude of the contrast effect is greater at the beginning of the component than at the end, then this change describes a transient contrast effect (Nevin and Shettleworth, 1966). A between-component analysis can also be made. Response rate changes between constant components as a function of preceding components describe sequential contrast effects. For instance, Terrace (1966) reported greater response rates during SD components when they followed SA components than when SD components followed SD components. O'Brien (1968) also reported sequential contrast effects: response rates during VI reinforcement were higher when a VI component followed an EXT component than when it followed another VI component.

One of the most commonly studied parameters in contrast investigations has been frequency of reinforcement. A substantial number of infra-human studies have presented evidence indicating that the magnitude of the contrast effect,
as defined by the change in response rate in the constant ply, is inversely related to reinforcement frequency in the other ply (Reynolds, 1961a, 1961b, 1961c, 1963; Reynolds and Catania, 1961; Catania, 1961; Bloomfield, 1967a, 1967b; Nevin, 1968). Although this array of evidence lends support to a functional relationship between relative frequency of reinforcement and magnitude of contrast it does not indicate that reduction in relative frequency of reinforcement is a necessary condition for the demonstration of contrast but rather a sufficient condition (Dunham, 1968).

Much less attention has been given to the study of the negative contrast phenomenon in within-subject infra-human research. While some studies (Nevin and Shettleworth, 1966; Reynolds, 1961b) have reported negative contrast, Terrace (personal communication to Dunham, 1968) failed to obtain negative contrast in two out of three birds when a mult VI 5-min VI 5-min schedule was changed to a mult VI 5-min VI 1-min. Additionally, Reynolds (1961a) reported that negative contrast effects are not as pronounced as positive contrast effects.

Only four studies investigating contrast phenomena have been conducted using humans as subjects. All four studies employed multiple schedules of reinforcement in which the two plys differed in relative reinforcement frequency.

The earliest of these studies was conducted by O'Brien (1968). The subjects were two retarded, inst...
adolescents who were reinforced with pennies for pushing a button on a mult VI 1-min EXT schedule. The components were 5-min long and presented in a semi-random order. Sequential contrast effects were generated by this schedule; response rates were higher during VI components immediately following EXT components than when following other VI components. As the number of successive EXT components that preceded a VI component increased, the rate of responding during that VI component increased. Conversely, response rates declined over succeeding VI components until another EXT component was presented. O'Brien, however, did not use an ABA design utilizing a baseline and return-to-baseline therefore making it impossible to measure sustained contrast effects.

Nicholson and Gray (1971), on the other hand, did report sustained contrast effects. Normal children received poker chips (not, however, backed up with other reinforcers) for lever pressing on a VI 1-min schedule of reinforcement in the presence of colored drawings of a space rocket oriented at 90° against a sky-blue background. After a number of such pre-discrimination sessions (although it was not indicated whether or not this baseline was stable) discrimination training was begun. Reinforcement was available on a VI 1-min schedule in the presence of the vertical rocket and no reinforcement was available in the presence of a sky-blue background with no rocket. There were an
equal number of 30-sec presentations of $S^D$ and $S^A$, presented in a semi-random order during each session. Three of the seven subjects showed no sign of learning the discrimination, and all of those showed decreasing rates of response in both $S^D$ and $S^A$. The other four subjects made a clear discrimination between $S^D$ and $S^A$, and in all four cases $S^D$ response rates by the end of discrimination training had exceeded the pre-discrimination baseline, as averaged over the last two days' pre-discrimination responding, by 125-1000 percent. These increases were consequently regarded as measures of sustained positive contrast effects.

Ray (1971) reported evidence of contrast effects in three institutionalized mental patients. These subjects were reinforced with pennies for pulling a single lever on a mult VI 1-min VI 1-min schedule. The schedule was then changed to mult VI 1-min EXT. Although all subjects showed a general decrease in response rate during extinction components, neither sustained nor sequential contrast effects were observed. During a second phase of the experiment the mult VI 1-min VI 1-min schedule was reinstated, however, the subjects now responded on different levers during each ply of the multiple schedule. After stabilization criteria had been met, the schedule was shifted to mult VI 1-min EXT. Two of the three subjects then demonstrated sustained positive contrast effects. One of these two also showed sequential contrast effects. Upon re-establishment
of the mult VI 1-min VI 1-min baseline condition all three subjects returned to their prior mult VI 1-min VI 1-min baseline levels of responding. In an attempt to facilitate production of contrast effects in the one subject who had not yet shown contrast, responding was eliminated during mult VI 1-min lock-out (LO) schedule by locking the operation of the lever which had been associated with EXT components. This procedure resulted in the production of both sustained and sequential contrast effects. The VI 1-min LO schedule was shifted back to the baseline condition and responding returned to its prior baseline level.

Waite and Osborne (1972) reported both positive and negative sustained contrast effects in six normal school children. Subjects pressed a lever for centavo pieces which were exchangeable for candies, games, and toys or could be used to operate a number of food or soft drink vending machines. Three of the subjects were exposed to a mult VI 20-sec VI 20-sec, mult VI 20-sec EXT, mult VI 20-sec VI 20-sec sequence of schedules. The other three subjects were exposed to a mult VI 20-sec EXT, mult VI 20-sec VI 20-sec, mult VI 20-sec VI 20-sec sequence. Schedule components were two minutes long and were systematically alternated. Both sustained positive and negative contrast effects occurred. Sustained positive contrast was illustrated by an increase in VI response rate along with a simultaneous decrease in responding during extinction during
the shift from mult VI VI to mult VI EXT. Negative contrast was evident in the decrease in rate in the constant VI component with the shift from mult VI EXT to mult VI VI. Transient contrast effects were not reported.

The focus of the present investigation was to investigate the generality of positive and negative contrast phenomena. To date the human subject population has been limited to institutionalized retardates, mentally ill residents, and children. Neither positive or negative contrast effects have been experimentally demonstrated in normal, non-institutionalized adults. Secondly, three different procedures for changing the relative reinforcement frequency in a multiple schedule of reinforcement were investigated. These procedures included increasing (VI 15-sec to VI 5-sec) as well as decreasing (VI 15-sec to EXT and VI 15-sec to RC VI 15-sec) the density of reinforcement. And thirdly, it was hypothesized that the production of both contrast effects as well as research efficiency would be facilitated by employing a single-session experimental design and within-session analysis of response rate changes. Previous studies have relied solely on multiple-session designs and between-session analyses.
METHOD

Subjects

Eighteen adults, six females and 12 males, ages 18-25 participated as subjects. Most of the subjects had either taken none or one psychology courses. None had taken more than two. Thirteen subjects were students attending Western Michigan University. Five subjects were members of the community of Kalamazoo.

Apparatus

The test apparatus was a specially constructed 19" x 21" console equipped with two Lindsley manipulanda situated 12" apart and centered 4" above the base of the console. Centered above each manipulandum were three stimulus lights. In the middle of the console 10" from the base was a Sodeco add-subtract counter with 1/4" digits. On each side of the counter was a single stimulus light. The console was mounted on a 34" x 54" table and a chair was placed in front of the console. This apparatus was housed in a room 10' x 13' x 12'. An overhead light controlled by a rheostat provided varying degrees of general illumination. Ventilation as well as masking of ambient noise was provided by a room air conditioning unit. Appropriate electromechanical equipment
were used to program the various schedules, provide feedback stimuli and record behavior. All recording and control apparatus were housed in a nearby room.

Procedure

Four different paradigms were employed in this investigation. The following procedures were common to all paradigms. All subjects received the same instructions upon entering the experimental room. They were told:

1. You can earn points by pulling levers.
2. The more points you earn the more money you can earn.
3. You can only earn points when the three lights above a lever are on.
4. This experiment is concerned with studying how the presentation of points affects your lever pulling behavior.

Initially the subjects' responses were reinforced with three points for "correct" lever pulling responses on a mult VI 15-sec VI 15-sec schedule—a two-ply schedule consisting of alternating 1-min components. In order to respond "correctly" the subject was required to move from one manipulandum to the other as the components of the schedule changed. A 4-sec time-out followed each component. During time-out the stimulus lights above each lever were extinguished. During this period responses were no longer effective in producing either feedback stimuli (an audible click following each response and three brief flashes of a
green light, when points were added, or of a red light, when points were subtracted) or reinforcement. This baseline schedule was in effect until the mean of five components in one ply varied no more than 10% from the mean of the preceding five consecutive components in the same ply.

The following procedures were specific to each of the four different paradigms.

**VI-EXTINCTION**

When the stabilization criterion was met a second phase was implemented. The stabilized component remained the same while the schedule for the other ply was shifted from VI 15-sec to EXT. This phase remained in effect until the mean number of responses occurring in the EXT component over a minimum of three consecutive components was no more than 10% of the total responding for the same period before EXT. After the subject either fulfilled this stabilization criterion or 30 EXT components has elapsed the schedule was returned to mult VI 15-sec VI 15-sec. The return to baseline continued until the mean number of responses occurring in three consecutive components in the constant ply varied no more than 10% from the mean of the previous three consecutive components in the constant ply. One subject, S4, was tested under this paradigm.
VI-EXTINCTION plus RESPONSE COST

This paradigm was similar to the preceding one with the exception that, if after 20 EXT components the subject had not met the EXT criterion, then a VI 15-sec response cost contingency (RC VI 15-sec) was added to the EXT ply. Not only were responses not reinforced during this ply they also resulted in a subtraction of three points. Points were subtracted on a VI 15-sec schedule from those existing on the counter. This phase remained in effect until the mean number of responses occurring in either the EXT or RC VI 15-sec ply over a minimum of three consecutive components was no more than 10% of the total responding for the same period before EXT or RC VI 15-sec. The schedule was then returned to the baseline phase and the session was terminated when the previously mentioned return-to-baseline criterion was met. Two subjects, S5 and S6, were tested under this paradigm.

VI-RESPONSE COST

When the subjects' responding met the baseline stabilization criterion the stabilized ply remained the same while the schedule for the other ply was shifted from a VI 15-sec reinforcement schedule to RC VI 15-sec. This phase remained in effect until the mean number of responses occurring in the RC VI 15-sec ply over a minimum of five consecutive components was no more than 10% of the total responding for the same
period before RC VI 15-sec. The minimum number of consecutive components was changed from three to five to allow more responding to occur once a discrimination had developed. These contingencies were then shifted back to baseline conditions and the session was terminated when the return-to-baseline criterion was met. Five subjects, S7, S9, S10, S11, and S12, were tested under this paradigm.

**VI 15-sec VI 5-sec**

Once baseline stabilization requirements were met the stabilized ply remained the same while the VI 15-sec ply was shifted to VI 5-sec. This phase was in effect until 20 VI 5-sec components elapsed. The VI 5-sec ply was then shifted back to VI 15-sec and the session was terminated when the return-to-baseline criterion was met.

Subjects were monetarily reimbursed with a check based on their accumulated points. Subjects in the VI-EXT, VI-EXT plus RC, and VI-RC conditions received one and a half cents per point while subjects in the VI 15-sec VI 5-sec condition received one cent per point. Funds for this research were limited; consequently, it was impossible to pay subjects in the last condition one and a half cents per point because they would end the session with more points than subjects in the other conditions. Payment of one cent per point resulted in approximately equal session payments for all subjects. Subjects were guaranteed payment of $5 for participating in the
research even if their accumulated points did not warrant such payment. One subject received $9.12 but most subjects were paid between $5 and $7.

The results of five subjects are not included. The results of two subjects were eliminated because of equipment failures. Three subjects were dropped because they seemingly failed to understand the directions. For instance, one subject revealed, after the session, that he thought points on the counter recorded mistakes, not points to be converted to cash. Another subject reported, after exhibiting near zero responding, that he believed he could only earn points when the green light was on. This light only came on as a consequence of earning points.
RESULTS

Response rates during each component were computed separately for each ply of the multiple schedule. Figures 1, 2, and 3 (see Appendix A) depict response rates for each subject throughout all phases of the experiment.

Figure 1 depicts response rate changes for three subjects, S4, S5, and S6. For all three, the mult VI 15-sec VI 15-sec baseline was shifted to mult VI 15-sec EXT. Subject 4 showed a decrease in responding during EXT but demonstrated no corresponding increase in VI 15-sec response rate (positive behavioral contrast). Neither S5 nor S6 showed a substantial decrease in responding during 20 EXT components and consequently the mult VI 15-sec EXT schedule was shifted to mult VI 15-sec RC VI 15-sec. Responding during the RC VI 15-sec components decreased, however, responding during VI 15-sec components generally remained stable for both S5 and S6. When the schedule was returned to baseline conditions S6 demonstrated a decrease in response rate in the constant component and the subject's overall responding for the session indicated a negative induction effect. The response rate for S5 returned to near-baseline level during reinstatement of baseline contingencies.

Figure 2 shows response rate changes for five subjects, S12, S10, S7, S9, and S11. When baseline conditions were
shifted from mult VI 15-sec VI 15-sec to mult VI 15-sec RC VI 15-sec all five subjects showed a decrease in responding during the manipulated RC VI 15-sec ply. Prior to the return-to-baseline condition all five subjects showed zero responding for at least the last two RC VI 15-sec components. Subject 12 showed a corresponding increase in responding during the constant components indicating evidence of positive contrast, while responding during the constant components remained generally stable for the other four subjects. Reinforcement of mult VI 15-sec VI 15-sec contingencies resulted in approximations of responding during the baseline condition with the exception of S11 who showed a marked increase in responding during the final 7 components of the session. Subject 9 received one non-response contingent reinforcer in component 37 to initiate responding.

Figure 3 depicts response rate changes for five subjects, S16, S16, S18, S17, and S14. The shift from mult VI 15-sec VI 15-sec to mult VI 15-sec VI 5-sec produced a slight transitory increase in responding during the manipulated components for S15 and S16, however, there was no evidence of a corresponding decrease in responding in the constant components for S16. There was a gradual decrease in responding in the constant components for S15, however, this was accompanied by a corresponding decrease in responding in later VI 5-sec components. Subject 17 showed a decrease in responding in the constant components but no corresponding
increase in responding in the manipulated components. Subject 18 and S14 did not demonstrate upward or downward trends in either the constant or manipulated components during the mult VI 15-sec phase. Upon reinstatement of baseline conditions, responding for all subjects was generally similar to responding at the end of the mult VI 15-sec VI 5-sec phase.

Table 1 (see Appendix B) shows the mean response rates per component for the last six components in each phase of the four experimental conditions. An increased response rate in the constant ply for a two-ply multiple schedule and decreased response rate in the manipulated ply defines positive contrast. Changes in responding when the baseline schedule was shifted for S4, S9, S10, S11, and S12 met the above definition but only S4 and S12 showed a subsequent decrease in responding during the ply when the return-to-baseline condition was reinstated. Subject 4 showed only a very slight positive contrast effect while S12 showed a substantial positive contrast effect.

A decrease in response rate in the constant ply and an increase in response rate in the manipulated ply defines negative contrast. The changes in responding during each of the three phases for S14, S15, S16, S17, and S18 did not indicate the presence of negative contrast effects. Subject 15, S17, and S18 all showed a decrease in responding during the constant ply when baseline conditions were
changed from mult VI 15-sec VI 15-sec to mult VI 15-sec VI 5-sec but there was no corresponding increase in responding during the manipulated ply. Subject 14, and S16 showed an increase in responding during the manipulated ply but no corresponding decrease in responding during the constant ply.
DISCUSSION

Dunham (1968) lists three conditions which others have considered as essential to the development of positive contrast:

(a) an increase in the relative frequency of reinforcement in the constant ply of a multiple schedule (Reynolds, 1961c), (b) an increase in the amount of non-reinforced responding in the manipulated ply (Terrace, 1963), and (c) a suppression in rate of responding in the manipulated ply (Terrace, 1966).

Eight of the 13 subjects were exposed to all three of these conditions but only two of the eight demonstrated positive contrast effects. The results of this study would then indicate that these conditions are not reliably sufficient for the demonstration of behavioral contrast.

Reynolds (1963) reported that the magnitude of contrast is very small for pigeons if pecking during the constant ply of a multiple schedule is reinforced at a high enough frequency (about 40 reinforcements per hour in his investigation). In the present study subjects responding during the VI 15-sec constant ply could have hypothetically received 240 reinforcements per hour. Waite and Osborne (1972), however, used a VI 20-sec schedule in the constant ply of their multiple schedule, which could have resulted in 180 reinforcements per hour, and yet reported significant sustained positive and negative contrast effects. It therefore appears that the high rate
of reinforcement frequency during the constant ply cannot account for the lack of positive contrast effects.

One possible reason for the failure of the development of negative contrast effects might be the relatively small change in reinforcement density in the manipulated component when mult VI 15-sec VI 15-sec was shifted to mult VI 15-sec VI 5-sec. Waite and Osborne (1972) reported sustained negative contrast effects; however, these effects developed after a shift from mult VI 20-sec EXT to mult VI 20-sec VI 20-sec. All five subjects in the present study who ran in the mult VI 15-sec VI 5-sec condition could identify the lever associated with the component which was shifted from VI 15-sec to VI 5-sec. However, none of the subjects reported this change in reinforcement density as being substantial and most of the subjects paused before choosing the lever which provided more points.

Ray (1971) reported an unpublished study in which human subjects operated a toggle switch for points which could later be exchanged for tokens. Subjects showed no decrease in response rates during EXT in a mult VI EXT schedule. In discussions following experimental sessions subjects discussed the different response "patterns" they had used to obtain points. Ray concluded that "this superstitious 'testing' of the contingencies would indicate the presence of as yet unspecified variables which may have impeded the progress of extinction" (p. 17). Such "testing" of the contingencies
might also have impeded the development of contrast effects in the present investigation. Subjects in this study revealed a variety of accounts of the operating contingencies in discussions following experimental sessions. Some subjects expressed a vague understanding that points would be available after a certain interval of time had elapsed but were unsure as to how response rates affected this time interval. Others indicated more "sophisticated" and "complex" explanations. One subject said he received points every time the lights above the lever (SD stimuli) went off and the green light (reinforcement feedback stimulus) went on, when in fact those stimulus changes were consequences and not antecedents of responding. Another subject indicated she could earn points by pulling the lever rhythmically as she sang Beatles' songs. One subject found some bare wires on the floor and remarked that he started receiving more points after he had connected two of the bare leads together. These wires had no functional relationship with the present study. It may be that normal, non-institutionalized adults do more contingency analysis and hypothesis testing, which might impede development of contrast effects, than infra-humans, children, retardates, or the mentally ill, all of whom have served previously as subjects demonstrating behavioral contrast effects. Continued testing might result in perseverance of steady states of responding during one stimulus condition in spite of procedural changes during
another stimulus condition.

The single-session experimental design employed in this study would appear to be a useful design which might make more efficient use of research time. Twelve of the 13 subjects met the baseline stabilization criterion within 27 components, that is, after only 54 min into the session. When the multiple schedule was shifted to include a response cost only, responding during those components dramatically and rapidly decreased. However, to determine whether or not this particular design served as a parameter which contributed to the lack of contrast effects, it would be necessary to run a concomitant study employing the more traditional multiple-session design.
FIGURE 1

RESPONSES PER MINUTE

- CONSTANT COMPONENT
- MANIPULATED COMPONENT

S-4

VI 15-VI 15

VI 15-EXT.

VI 15-VI 15

S-6

VI 15-VI 15

VI 15-EXT.

VI 15-RC

VI 15-VI 15

S-5

COMPONENTS

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FIGURE 2

Response rates per minute for both plys of the multiple schedule during mult VI 15-sec VI 15-sec, mult VI 15-sec RC VI 15-sec, mult VI 15-sec VI 15-sec for S7, S9, S10, S11, and S12.
Response rates per minute for both plys of the multiple schedule during mult VI 15-sec VI 15-sec, mult VI 15-sec VI 5-sec, mult VI 15-sec VI 15-sec for S14, S15, S16, S17 and S18.
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Table 1. Mean response rates per component averaged over the last 6 components in each phase of the four experimental conditions.

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