THE EFFECTS OF RATE OF POINT REINFORCEMENT ON HUMAN PREFERENCE BEHAVIOR

By

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This dissertation is dedicated to

my mother and father.

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Two normal 15-year-old children were exposed to concurrent-chained schedules with equal and independent variable-interval schedules in the initial components and different-valued variable-interval schedules of point reinforcement in the terminal components. Points were later exchanged for money. A changeover-key procedure was used in which responses under either chained schedule were made with one plunger-type operandum. Responses which produced a changeover from one initial chained component to the other were made on a second operandum. The relative overall response rate and the distribution of relative time spent in the initial components showed a preference for the terminal component associated with the higher rate of reinforcement. Preference approached a matching relationship to the relative rate of point delivery. These results extend the species generality of concurrent-chains research to humans as well as extending methodological generality through use of a novel procedure.

INTRODUCTION

The concurrent-chained-schedules procedure was introduced by Autor (1960) as a method for evaluating the relative strength of conditioned reinforcers. In this procedure the organism, typically a pigeon, responds on two concurrently available keys, each of which is illuminated by the stimulus associated with the initial component of one of the chains. Responses on each key occasionally produce the stimulus for the terminal component of the chain on that key. Presentaton of the terminal component stimuli is typically arranged by equal and independent variable-interval (VI) schedules in the initial components. Responses in the presence of either of the mutually exclusive terminal-component stimuli produce primary reinforcement such as food. The relative conditioned-reinforcing strength of the stimuli associated with the terminal components has been inferred from the relative response rate in the initial chained components. The validity of this inference has been challenged by studies which suggest that responding may be maintained in initial components by delayed primary reinforcement (Neuringer, 1969; Schneider, 1972). In addition, Duncan and Fantino (1972) reported that terminal chained components which were divided into two or three chained

segments were less preferred than components of equal duration which consisted of only one or two chained segments. Currently, relative response rate in initial components of concurrent-chained schedules is discussed as a measure of preference *per se*, without necessarily implicating conditioned reinforcement as the causal process.

Early research with concurrent-chained schedules employing variable-ratio (VR) and VI schedules of primary reinforcement reported a matching relation between preference and the relative rate of reinforcement in the terminal components (Autor, 1960; Herrnstein, 1964a). Herrnstein (1964b), comparing fixed-interval (FI) *versus* VI schedules of primary reinforcement, determined that the matching relation had limited generality. In that study, FI schedules were less preferred than VI schedules of equal average duration. Killeen (1968) reported that preference between FI *versus* VI schedules and VI *versus* VI schedules matched the relative harmonic rate of reinforcement, also called the relative immediacy of reinforcement. Preference predictions based on the relative immediacy of reinforcement give greater weight to short inter-reinforcement intervals in aperiodic schedules than predictions based on the relative arithmetic rate of reinforcement. Later studies of preference between FI schedules, and between FI *versus* mixed-interval (MI) schedules of primary reinforcement, reported that preference matched a transformation

based upon a power function similar to the relative immediacy of reinforcement but with a slightly smaller exponent (Davison, 1969, 1972; Killeen, 1970). Davison (1969) speculated that the value of the power function exponent necessary to achieve matching might be related to the number of intervals in the aperiodic schedules, but this was later discounted (Davison, 1972).

In a study of preference between periodic schedules (FI versus FI and FR versus FR) Duncan and Fantino (1970) held the absolute difference between the schedules of primary reinforcement constant, and increased both schedule values by equal amounts. As the values were increased, both the relative immediacy of reinforcement and the relative rate of reinforcement for both schedules approached 0.50. Nevertheless, preference for the schedule with the smaller value increased as the schedule values were increased. A similar finding was reported by MacEwan (1972), who increased the absolute durations of terminal-component FI and VI schedules while holding the relative immediacies of reinforcement constant. This study also found departures from matching as the schedule values were increased, no matter what transformation of the relative immediacy of reinforcement was employed.

The value of the initial-component VI schedule was found to influence preference (Fantino, 1969a; Squires and Fantino (1971). In the former study, the VI schedules of

primary reinforcement were held constant but unequal, and the values of the initial-component VI schedules were varied. Matching predicted from the relative rate of primary reinforcement was not obtained. In the latter study, the VI schedules of primary reinforcement were held equal and the relative size was varied of unequal VI schedules in the initial components. Preference was predicted in both studies by a formula which took into consideration the reduction in expected time to reinforcement associated with each initial component schedule, and in the latter study by a modified formula which also took into consideration the overall rate of primary reinforcement on each key. Additional variables which may influence preference include number of primary reinforcements in each terminal component (Fantino and Herrnstein, 1968; Squires and Fantino, 1971), high response rate in a terminal component (Fantino, 1968; Arnett, 1972), and the presence of a changeover delay (COD) for responding in the initial components (Davison, 1972).

Although a number of studies have reported human performance on concurrent schedules of reinforcement (e.g., Frazier and Bitetto, 1969; Sanders, 1969; Schroeder and Holland, 1969; Poppen, 1972), the focus in most of these studies has been on variables influencing patterns of responding in separate components, rather than on variables influencing preference. An exception was the study by

Schroeder and Holland in which subjects matched relative-eye-movement rates to the relative rates of reinforcement associated with concurrent VI schedules. Matching was only obtained, however, when a COD was programmed. No reports of human concurrent-chained-schedule performance have appeared in the experimental literature.

The purpose of the present experiment was to determine the effects on human preference of different combinations of VI schedules in the terminal components of two concurrent chains. Responses in both chains were made on one operandum. Changeovers from one initial component to the other were produced by responses on a second operandum. This type of concurrent-chains procedure is analogous to the change-over-key (CO-key) procedure used in many studies with single-component concurrent schedules (e.g., Findley, 1958; Brownstein and Pliskoff, 1968; Stubbs and Pliskoff, 1969).

METHOD

Subjects

Two 15-year-old boys (F. H. and S. G.), who answered an advertisement in a newspaper, served. They were both told that they could earn up to $1.00 per session depending on their performance. Half of the money earned was paid immediately following each session and half was paid at the conclusion of the subject's participation in the experiment.

Apparatus

The intelligence panel consisted of the side of a wooden box 60 cm wide and 64 cm high which was secured to the top of a metal desk which was 75 cm in height. Each subject sat in a chair in front of the panel. In the upper half of the panel there was a row of three translucent screens which were 12.5 cm wide and 13 cm high. The screens were illuminated from the rear by standard-size, 7.5-w Christmas tree lights, two bulbs for each color employed. The colors were yellow or red behind the left screen, white behind the center screen, and blue or green behind the right screen. An additional screen 32.5 cm wide and 7.5 cm high was centered above the other three. This screen was illuminated by a pink light. Two Lindsley plunger-type operanda

were located 19 cm below the screens and 42 cm apart. A counter was centered on the panel at a height intermediate between that of the operanda and that of the translucent stimulus screens. A small white light was located immediately above the counter. Two speakers, 10 cm in diameter, were located behind grids in the panel on either side of the counter. A tone and clicking sound were presented through one speaker and white noise was presented as a masking noise through the other. Additional masking noise was provided by an exhaust fan in one wall. The room was dimly illuminated by a shielded flourescent light located on top of the box, above the intelligence panel. The subjects were observed during experimental sessions through a "peephole" with a wide-angle lens located in the door to the room.

Procedure

When each subject entered the experimental room, his watch was taken from him and he was seated in front of the intelligence panel. During the initial session the right operandum was covered. The right operandum will be referred to as the changeover (CO) operandum. At the beginning of the first session, each subject was instructed that he could pull the left or main operandum and that sometimes when he pulled it, he would earn a point on the counter. He was further instructed that he would be paid one cent for each point earned. Every response produced a 0.25-sec flash of

the pink screen. The point-delivery cycle consisted of the presentation of a 2-sec tone and simultaneous illumination of the white center screen followed by a 45-msec flash of the light above the counter and a 1-point counter advance. Sessions were scheduled daily, five days per week, but occasional subject absences occurred. Each session was begun and terminated with a 5-min blackout during which there was no illumination of the screens on the intelligence panel and responses had no programmed consequences. Neither subject showed any responding during these blackouts after the first session. Each session was terminated after 100 points had been earned or after the passage of one hour, whichever occurred first.

During the initial sessions, a clicking sound was continuously present and either the red light behand the left screen or the blue light behind the right screen was illuminated. In the presence of either the red or the blue light, responding on the main operandum produced points according to independently programmed VI 15-sec schedules of point delivery. All schedules in the present experiment consisted of 15 intervals selected according to a progression (Fleshler and Hoffman, 1962) that generates VI schedules in which the probability of reinforcement is approximately constant with respect to time elapsed since the last scheduled outcome. The light color and associated VI schedule were changed after every point delivery.

In the third session, responding on the main operandum in the presence of the yellow light behind the left screen produced the red light and clicking sound according to a VI 15-sec schedule. Responding in the presence of the red light and clicking sound produced points according to a VI 15-sec schedule of point delivery. This sequence will be designated as Chain 1. Responding on the main operandum in the presence of the green light behind the right screen produced the blue light and clicking sound according to a VI 15-sec schedule. Responding in the presence of the blue light and clicking sound produced points according to a VI 15-sec schedule of point delivery. This sequence will be designated as Chain 2. Point delivery in Chain 1 was followed by presentation of the Chain 2 initial-component stimulus. The entire sequence constitutes a multiple (mult) (chain VI 15-sec VI 15-sec)(chain VI 15-sec VI 15-sec) schedule. Figure 1 shows a diagram of this procedure.

In the fourth session the procedure was the same as that described above except that the CO-operandum was uncovered. A response on the CO-operandum during either initial-chained component produced the stimulus associated with the other initial component. The programming devices for both initial-component VI 15-sec schedules operated simultaneously, independent of which component was in effect. With the addition of the CO-operandum, the procedure becomes a concurrent (conc)(chain VI 15-sec VI 15-sec)(chain VI 15-sec VI 15-sec) schedule.

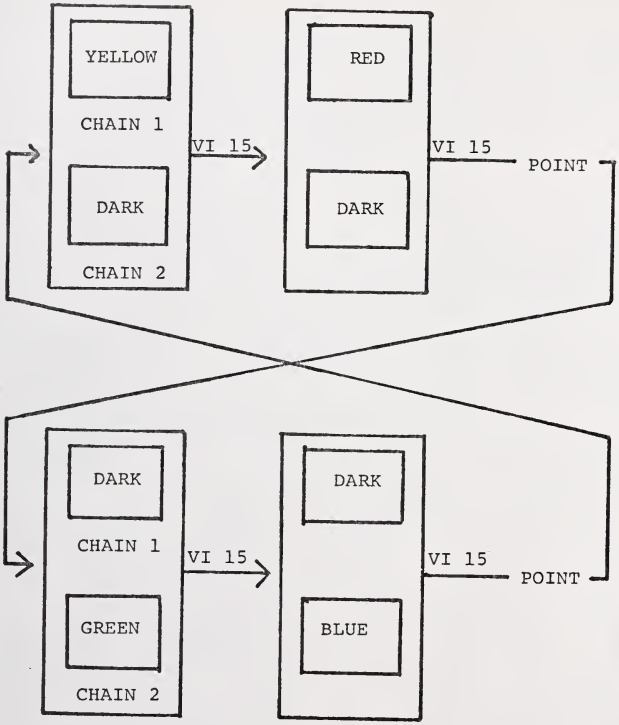

Figure 1. Diagram of the mult (chain VI 15 sec VI 15 sec) (chain VI 15 sec VI 15 sec) procedure.

After stable responding was observed under this schedule for each subject, the schedule of point delivery in the terminal component of Chain 1 was changed to VI 60 sec. After stability was observed a second time, the Chain 1 terminal-component schedule was changed back to VI 15 sec and the Chain 2 terminal-component schedule was changed from VI 15 sec to VI 60 sec. Responding was judged to be stable when the relative response rates in both initial and terminal components showed no systematic trend. The relative response rate in the initial components was calculated by the number of responses in the Chain 1 initial component divided by the total responses in both initial components. The response rate in the terminal component was calculated by the local response rate (number of responses divided by time in that component) for Chain 1 divided by the local response rates for both Chain 1 and Chain 2. A summary of the schedules of point delivery and the number of sessions each was employed is presented in Table 1.

TABLE 1

THE NUMBER OF SESSIONS AT EACH SCHEDULE OF POINT DELIVERY

F. H.			S. G.		
Chain 1	Chain 2	Sessions	Chain 1	Chain 2	Sessions
VI 15 sec	VI 15 sec	12	VI 15 sec	VI 15 sec	15
VI 60 sec	VI 15 sec	9	VI 60 sec	VI 15 sec	6
VI 15 sec	VI 60 sec	6	VI 15 sec	VI 60 sec	6

RESULTS

Figure 2 depicts the median relative response rate from the last five sessions at each schedule as a function of the mean relative rate of reinforcement for both subjects. A matching relation is represented by the diagonal broken line. The data for subject S. G. show a close approximation to matching with slightly less preference for the schedule of point delivery with the smaller value than is predicted by the relative rate of reinforcement. The data for subject F. H. reflect indifference between the equal-valued schedules of point delivery but show greater preference for the smaller-valued schedule than would be predicted on the basis of the relative rate of reinforcement.

Figure 3 depicts the relative time spent in each initial component as a function of the mean relative rate of reinforcement for both subject during the last five sessions at each schedule. Once again, the preference of subject S. G. closely approximates a matching relation with only slightly less preference than is predicted by a matching relation for the smaller-valued schedule of point delivery for one schedule combiantion. Subject F. H. showed greater preference for the smaller-valued schedule of point delivery than predicted by matching.

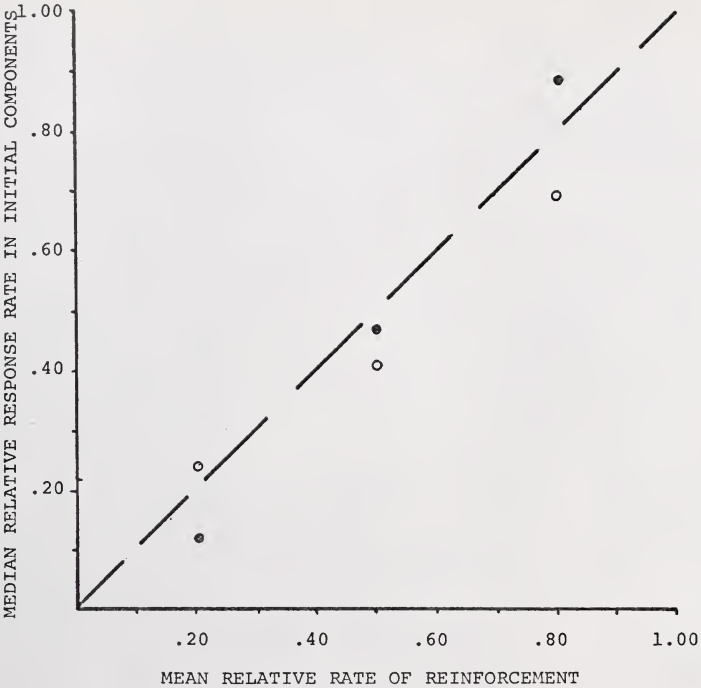

Figure 2. The median relative response rate in the initial components as a function of the mean relative rate of reinforcement. Values are from the last five sessions at each schedule for subjects F. H. (closed circles) and S. G. (open circles).

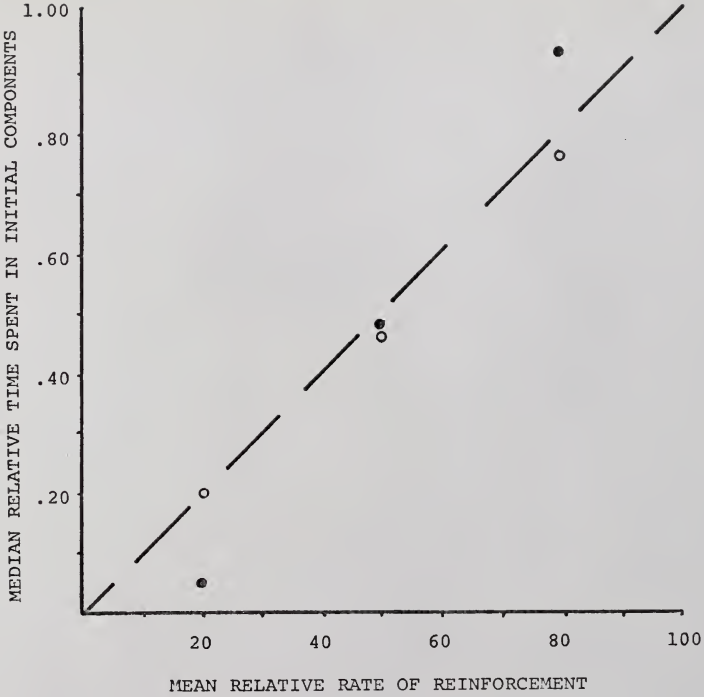

Figure 3. The median relative time spent in initial components as a function of the mean relative rate of reinforcement. Values are from the last five sessions at each schedule for subjects F. H (closed circles) and S. G. (open circles).

Figure 4 shows the median and range of the relative response rates in the terminal components from the last five sessions at each schedule. Subject S. G. showed a slight increase in relative response rate followed by a decrease under the second and third schedules respectively. The median relative response rates under the second and third schedules did not vary outside the range of relative response rates obtained under the first schedule. To the extent that such a trend can be detected, it would reflect a higher relative response rate in the terminal component with the lower rate of point delivery. Subject F. H. showed consistantly higher response rates in the terminal component of Chain 1.

Figure 5 shows a cumulative record of the responding of subject S. G. during the final session under conc (chain VI 15-sec VI 15-sec)(chain VI 15-sec VI 15-sec). Records A and B show responding in the initial components of Chains 1 and 2 respectively. Slash marks of the response pen indicate presentation of the terminal component stimuli. Both cumulative recorders operated during either initial component. Record C shows responding in both terminal components. Responding in the terminal component of Chain 1 is shown with the response pen deflected upwards, and responding in the terminal component of Chain 2 is shown with the response pen deflected downward. Slash marks of the event pen indicate point delivery. The cumulative recorder

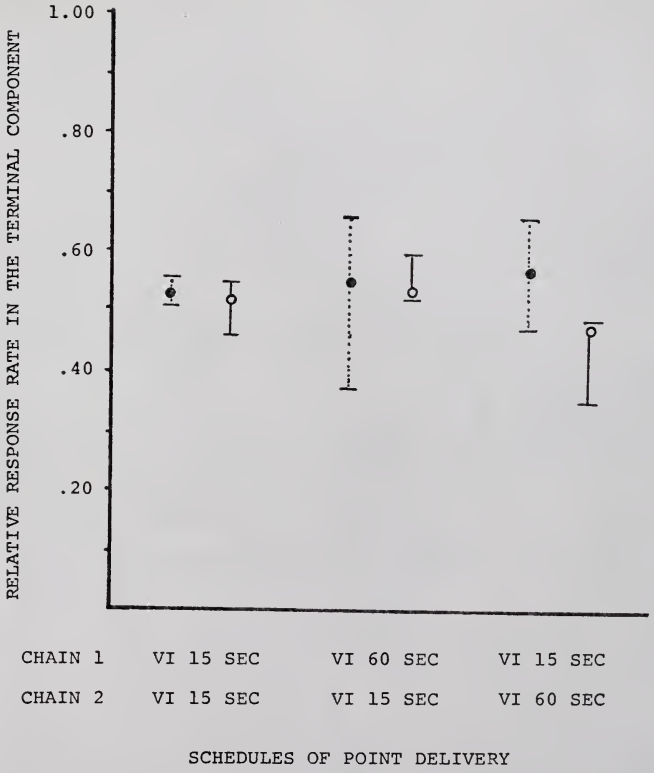

Figure 4. The median and range of the relative response rate in the terminal component from the last five sessions at each schedule for subjects F. H. (closed circles) and S. G. (open circles).

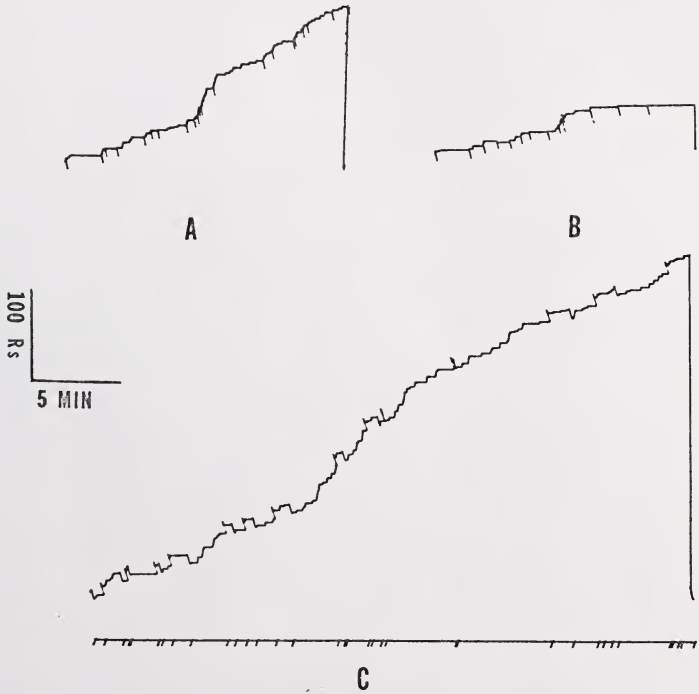

Figure 5. A cumulative record of the responding of S. G. during the final session under conc (chain VI 15-sec VI 15-sec) (chain VI 15-sec VI 60-sec). Records A and B show responding in the initial components of Chain 1 and Chain 2. Slash marks of the response pen indicate presentation of a terminal chain component. Record C shows responding in the terminal components. Responding in Chain 1 is shown with the response pen deflected upward, and responding in Chain 2 is shown with the response pen deflected downward. Slash marks of the event pen indicate point delivery.

operated during both terminal components. The higher response rate in the initial component of Chain 1 is reflected in the steeper slope of record A. The pattern of responding in all three records is one of brief periods of high rate responding followed by short pauses. Pauses in records A and B are often the occasions for responding in the other initial chain component. These same pauses are seen in record C, however, when there are no programmed consequences for alternative responses.

DISCUSSION

Briefly, the results of the present experiment include some of the following points: 1) The relative response rates of human subjects display preference for the schedule in the terminal concurrent-chained component with the higher rate of reinforcement. 2) The distribution of time between initial concurrent-chained components constitutes a measure of preference showing a very similar relation to relative rate of point delivery as relative response rate. 3) The changes in relative response rate as the schedules of point delivery are varied are seen only in the initial chained components rather than reflecting a generalized change in response rates throughout each chain. 4) The present findings generally replicate those in the concurrent-chain literature through use of a CO-key procedure.

The first summary statement must, of necessity, be conservatively worded. The measure of frequency of reinforcement which most closely matched the measures of preference for both subjects is one which has been found to have limited generality and questionable reliability. Although relative rate of reinforcement most closely matched the preference of both subjects, relative immediacy of reinforcement provided at least as good an approximation to

matching for subject S. G. The relative immediacy of reinforcement would suggest less preference for the schedule with the lower value than predictions based on the relative rate of reinforcement. This was the direction in which the preference of subject S. G. deviated from matching the relative rate of reinforcement. The preference shown by subject F. H., on the other hand, deviated from matching the relative rate of reinforcement in the opposite direction. One variable which has been shown to generate more extreme preference such as that seen with subject F. H. is large absolute magnitude of the schedules in both terminal components (Duncan and Fantino, 1970; MacEwan, 1972). It is difficult to imagine that FI 15-sec and FI 60-sec schedules would be of sufficient absolute magnitude to produce such an effect, even taking possible inter-species differences into consideration.

Baum and Rachlin (1969) and others have suggested that time allocation among alternatives may provide a better measure for studying preference than relative response rate. The procedure employed in the present experiment permits a comparison between these two measures. In general, quite similar preference was described by both of them. The present experiment constitutes a first inter-species replication in a paradigm that is fraught with unresolved contradictions and is hardly the proper place for a critical comparison of these two measures to be made. The precision

of experimental control which characterizes the better research with pigeons makes that species a far better choice at present.

The fact that the present results have generally replicated findings from other concurrent-chains research, suggests that direct comparisons can be made between concurrent-chained-schedule experiments using the two different procedures. The same advantages which have brought the CO-key procedure into widespread use in research with simple concurrent schedules recommend it for use with concurrent chains as well. Schneider (1972) recently has urged that caution be used in interpreting the response rates maintained in initial concurrent-chained components. His research suggests that it may be difficult to evaluate the effects of delay of primary reinforcement as a confounding influence on relative response rate as a measure of preference. In this regard, time allocation in the initial components of concurrent-chained schedules could prove to be a useful addition to current measures of preference.

APPENDIX

REVIEW OF HUMAN OPERANT RESEARCH

This review is intended to provide representative, if not exhaustive coverage of the research into human operant behavior in which intermittent schedules of positive reinforcement have been employed. The organization will reflect this emphasis on the various schedules of reinforcement. Within each major subdivision, the order of coverage reflects the subjects used in descending order as to age, and from normals to retardates and psychotics.

Fixed-Ratio Schedules of Reinforcement

Perhaps the simplest schedule of reinforcement is the fixed-ratio schedule (FR), in which every n^{th} response is followed by reinforcement. The limiting cases define continuous reinforcement (where n equals unity) and extinction (where n equals infinity). The pattern of responding typically generated by FR schedules in infrahuman species is characterized by a high terminal response rate. As the value of the FR schedule is increased, pauses occur typically after reinforcement, producing a bi-valued pattern of response rates (Ferster and Skinner, 1957).

Holland (1958a) employed FR schedules in his investigation of human observing or monitoring behavior. In this

study, normal adult males (Navy enlisted men) were required to press a key to briefly illuminate a dial so that they could report deflections of a pointer on that dial. In this study Holland demonstrated that the observance and reporting of pointer deflections (which reset the pointer) reinforced the behavior of lever pressing to illuminate the dial. Thus an FR schedule was programmed by following every $\underline{n}^{th}$ observing response with pointer deflection. The behavior generated by FR schedules of 36, 60, 108, 150, and 200 responses was characterized by high, steady observing-response rates with occasional brief pauses which occurred after signal detection. Holland (1958b) has also reported a different and atypical pattern of responding generated by FR schedules with one subject which was characterized by a high post-reinforcement rate followed by a lower rate, which was in turn followed by a high rate immediately prior to reinforcement. Upon inquiry, it was learned that the subject was counting the responses as he emitted them. Holland then instructed several other subjects to count. The patterns of responding displayed by these subjects showed an accelerated rate prior to reinforcement, but not afterwards.

In another study in which normal adults served as subjects (Weiner, 1964a), button pushes were reinforced by the addition of 100 points to a counter mounted in front of the subject. An FR 50 schedule generated high terminal rates of pushing without any pauses. Pauses were produced, however,

when 5-sec periods of punishment were programmed immediately after reinforcement. The loss of 1 or 2 points from the counter (response cost) constituted punishment. When response cost was programmed continuously, response rates and patterns were essentially the same as when no cost was programmed, as long as the cost was less than the reinforcement. Rapid cessation of responding occurred when continuous response cost was made equal to reinforcement.

The behavior of normal children from the ages of four to eight years under FR schedules of reinforcement was investigated by Long, Hammack, May, and Campbell (1958). The response used was a telegraph key press or a Lindsley manipulandum pull, and reinforcers included pennies, trinkets, and colored slide projections. The values of FR schedules employed ranged from FR 5 through FR 150. The pattern of responding observed closely resembled that previously reported for lower organisms. A problem which plagued this investigation, however, was the apparent deterioration of the reinforcing properties of the pennies and trinkets used. For example, first session FR schedules of 20 responses or less, frequently produced a deceleration of overall rate, characterized by increases in length of pausing, intermediate rates, negative curvature, and grain. Increasing the schedule requirement from around FR 25 to FR 60 by the end of the first 20-min session usually produced high, steady rates with a minimum of pausing. Even the performance of

subjects who showed good ratio patterns of responding at the higher schedule values also began to show deterioration after five or six weekly sessions. It was demonstrated that this poor schedule control at low FR values, or extended exposure to higher FR values, was due to satiation effects, by the temporary improvement produced by increasing the period between sessions and by introducing new trinkets.

Performance under FR schedules in normal school children has been investigated by Rhinegold, Stanley, and Doyle (1964) with subjects age two to five years and in infants 11 to 19 months by Simmons (1964) and Weisberg and Fink (1966). Using short durations of music and movie projection as reinforcement, Rhinegold _et al_. observed high, steady rates at FR schedules which were gradually increased to FR 18. Using chimes as reinforcement, Simmons only marginally demonstrated conditioning on an FR 2 schedule. Moderately good FR performance was reported by Weisberg and Fink using cookie bites as reinforcement at schedules of up to FR 15. Deviations were primarily in the form of variable-length, post-reinforcement pauses.

In a study in which adult retardates served as subjects, Ellis, Barrett, and Pryer (1960) reported FR performance in several subjects which closely resembled that of lower organisms. The cumulative records of most subjects, however, showed various atypical features, the most noticeable of which were broken "runs" and other indications of "strain."

Post-reinforcement pauses under schedules as low as FR 10 were also observed in many subjects. Another unusual feature was the high resistance to extinction shown by many subjects. Perhaps the most striking aspect of this study was the considerable variability between subjects in performance.

By comparison to the data reported above, that generated by chronic schizophrenics was much more typical FR performance (Hutchinson and Azrin, 1961). Pausing at low FR values was rare, and, even at values up to FR 20, pauses were brief and infrequent where the schedule values had been gradually increased. Those instances of pausing and strain which were observed were largely attributed to overly rapid increasing of the FR schedule requirement because the deviations observed were readily eliminated by lowering the FR schedule and more gradually increasing it again. The experimenters concluded that "the results of the experiments are highly similar to those obtained in studies of infra-humans and normal humans. The one exception to this essential similarity is the extended period of time necessary to produce high rates of responding."

In a study with inpatient retarded children, Barrett and Lindsley (1962) reported poor FR performance. The cause for this was not clear, however. First, the procedure employed two manipulanda, each of which was below a light. Responding on one manipulandum was never reinforced,

regardless of whether the light above it was on or not, and responding on the other manipulandum was reinforced only in the presence of the light above it: hence, a conc mult FR EXT mult EXT EXT schedule. Higher rates were reported under FR 1 and FR 3 than under FR 10, and intra-session variability was considerable. The analysis of schedule control in this study was complicated by apparent stimulus-control problems.

Rather typical FR performance was reported by Ferster and DeMeyer (1961) in a study with two inpatient autistic children. The schedule values were never very high, however, being increased only to FR 30. Pauses were quite frequent, although rarely occurring during a "run." A different sort of indication of usual FR schedule control was the disappearance of some "superstitious" behaviors when the schedule was changed from VI to FR.

Variable-Ratio Schedules of Reinforcement

"In a variable-ratio (VR) schedule of reinforcement, the reinforcement occurs after a given number of responses, the number varying unpredictably from reinforcement to reinforcement" (Ferster and Skinner, p. 391, 1957). The value of the VR schedule denotes the average number of responses required for reinforcement. Orlando (1961b) employed a VR 100 schedule of reinforcement in a discrimination study with retardates serving as subjects. Details of the experimental findings will be presented under "concurrent

schedules," but in summary, the pattern of behavior observed was one of steady, high-rate responding, with little pausing. In a study by Scobie and Kaufman (1969) of intermittent punishment, one baseline was key-pressing behavior maintained by a VR 210 schedule of points exchangeable for money. College females served as subjects. Again, steady, high-rate responding was obtained.

Fixed-Interval Schedules of Reinforcement

In a fixed-interval (FI) schedule of reinforcement, the reinforcement follows the first response after a non-varying interval of time has elapsed (Ferster and Skinner, 1957). In the previously discussed investigation of human monitoring behavior, Holland (1958a) also employed fixed-interval schedules of reinforcement, i.e., the first dial-illuminating response (observing response), after a constant period of time since the last detection had elapsed, produced a pointer deflection. Normal adult males were exposed to eight 30-min sessions, at each value, which were 1/2-, 1-, 2-, 3-, and 4-min FI schedules of pointer deflections. The pattern of responding generated under all schedule values was identical to that produced by various infrahuman species under FI schedules of positive reinforcement (Ferster and Skinner, 1957). Pausing occurred immediately after reinforcement. Then response rates shifted to a high terminal rate which was maintained until deflection occurred. The shift from a zero to high rate was usually gradual, but was

often rather abrupt. As the FI value was increased, the pause duration increased as well.

Later investigations have indicated, however, that this "scallop" pattern may frequently not be observed and have determined a number of variables which may influence the pattern of responding. Weiner (1964c), in a study with normal adults in which key pressing was reinforced with the addition of 100 points on a counter, found that the pattern of responding generated by an FI 10-sec schedule of reinforcement was greatly different for subjects who had previous exposure to an FR schedule compared to subjects with previous exposure to a schedule differentially reinforcing low rates of responding (DRL). The former subjects responded continuously through the interval with high, steady rates, while the latter responded at very low rates, typically pausing until after the 10 sec elapsed before emitting the first response. In an investigation with similar subjects and the same response and reinforcer, Weiner (1962) studied the effects of a response-cost contingency on responding under an FI 1-min schedule. When each response did not produce point loss, a constant rate of responding was maintained throughout the interval. Under the response-cost contingency, however, the rate was greatly reduced, with pausing after reinforcement followed by a low, slightly accelerated response rate. Removal of the response-cost contingency produced a reversal to the previous pattern of

of responding maintained throughout the interval. Imposing the response-cost contingency in either the first or last half of the interval produced pausing followed by sustained responding and sustained responding followed by pausing, in the respective conditions. Following performance similar to that described above, Weiner (1964b) instituted periods of cost or no cost with a distinctive stimulus paired with either condition and programmed extinction (no points) for key pressing. During extinction all subjects showed considerable responding during the no-cost period, but suppressed almost completely when the response-cost contingency was in effect.

Baron, Kaufman, and Stauber (1969) reported adults' behavior under a multiple schedule of five different FI schedules of monetary reinforcement. The subjects who were uninstructed about the FI schedules responded at high and generally equivalent rates regardless of the particular component. By comparison, subjects given instructions about the schedules showed an orderly progression of rates and temporal patterning as a function of the inter-reinforcement interval. When response-cost was imposed, both instructed and uninstructed subjects showed low and differentiated rates. Weiner (1969) reported that not only do subjects with histories under FR schedules and DRL schedules respond in the previously described fashion under FI schedules, but also that subjects with both DRL and FR histories tend to pause after reinforcement and respond at relatively low rates.

Azrin (1958) reported that increasing the force required to make a response produced an effect similar to increasing response cost on responding under FI schedules. When the key- or button-pressing response required little force (about 12 g) responding occurred throughout the 3-min fixed intervals employed in that study. When the force required was increased to several hundred grams, much lower rates were found and greater acceleration of rate within each interval. This is consistent with Weiner's (1962, 1964b,c) findings under no-cost conditions where the force required for key depression was reported to be 20 g. The force required in the Holland (1958a,b) studies is not known.

Laties and Weiss (1960) employed a vigilance procedure (ref. Holland 1958a) to investigate the occurrence of responding immediately after reinforcement under an FI schedule. Identifying the variables controlling this post-reinforcement responding was of interest because pausing usually occurs after reinforcement. Laties and Weiss found that the frequency of the occurrence of this post-reinforcement responding could be increased by either occasionally causing the pointer-reset response to be ineffective or by suggesting to the subject that the reset button was operating imperfectly. Post-reinforcement observing responses could be decreased by accompanying the previously silent reset with a loud auditory stimulus.

The response patterns under FI schedules in another study by Laties and Weiss (1963) were similar to those reported by Holland (1958a) and Laties and Weiss (1960), with pauses followed by abrupt shifts to high terminal rates. The particularly high terminal rates found here were produced by the addition of a "limited hold" contingency where the deflected pointer was reset automatically if not detected within a limited period of time. These subjects had also been instructed as to how frequently the pointer was deflected. After a few sequences of responding in the above described manner, subjects were instructed to do successive subtractions backwards from 1,000. The pattern of observing responses was changed, in that pausing was shortened slightly and the increase in response rate was much more gradual. Laties and Weiss concluded that the frequently observed patterns of FI responding in humans is mediated by some sort of counting or timing behavior. Disruption of this behavior produced a pattern more nearly like the scallops produced by lower organisms.

Recently some investigators have questioned the importance of response effortfulness and suggested yet another variable. Lippman, Leander, and Meyer (1970) varied the force required for a button-pressing response from 20 g to 1,200 g. They also varied whether the initial point (reinforcer) was delivered after the first or the second response. The schedule by which points were delivered was otherwise

FI 20 sec. They concluded that neither variable exerted significant control over button-pressing behavior. Leander, Lippman, and Meyer (1968), using the same apparatus with the "light" (20 g) button, varied the FI schedule from FI 20 sec to FI 40, 60, and 80 sec. Results indicated that the pattern of responding was highly correlated with the subjects verbalization of the reinforcement contingency. The subjects who were instructed or who afterwards reported that points were delivered after a certain period of time showed lower rates and much pausing in their terminal, if not initial, performance. This latter group was more likely to show indications of scalloping. Factors which may have influenced the Lippman et al. (1970) and Leander et al. (1968) results include the rather brief exposure of each subject to the contingency (approximately 50 reinforcements) and the short-interval durations used (the longest was 80 sec). In addition, the "effortful" response required 35% less force than that used by Laties and Weiss (1960, 1963).

Long et al. (1958) investigated the behavior of normal children reinforced with candy, trinkets, and color-slide pictures on FI schedules ranging from 0.5 min to 3 min in duration. The subjects who were begun on a 1-min variable-interval (VI) schedule and switched to FI 1 min, or begun on FI 1 min, showed more evidence of scalloping than subjects begun on FI 0.5 min or a low FR schedule and switched to FI 1 min. This is similar to the historical influences on

FI performance reported by Leander et al. (1968). Children's performance also frequently showed deviations such as knees, multiple runs, second-order effects, and negative acceleration. The difficulty experienced in the investigation with "weakening" reinforcers, which was noted earlier, may well be related to the variability in the patterns of responding reported here.

Bijou (1958) compared the performance in extinction of four normal four-year-old children who had been responding on an FI schedule with trinket reinforcers distributed according to an increasing ratio, i.e., requiring increasing numbers of FI sequences to be completed before trinket delivery. Interval durations varied between subjects, either 20, 30, or 60 sec. Response rate and number of responses in extinction were directly correlated to duration of the interval. Only extinction data were presented. Cumulative records more closely resembled that of FR extinction than FI extinction in that more bi-valued responding was apparent than gradual increases to high rates.

Patterns of responding of adult retardates under an FI 1-min schedule of candy or cigarette reinforcement (Ellis et al., 1960) were extremely variable between subjects. The ratio-like high rates shown by many subjects may be related to the fact that on 11 of the 12 sessions prior to initiation of the FI 1-min schedule, FR schedules had been in effect. There is little resemblance between the cumulative

records of these subjects under FI 1-min and FI patterns of responding of humans or any other species reported in the literature. Orlando concluded that "temporal discriminations observed under FI schedules of reinforcement are related to at least two behavioral components: the use of the temporal interval as a discriminative stimulus, and withholding from responding in the presence of stimuli associated with non-reinforcement."

Variable-Interval Schedules of Reinforcement

In a variable-interval (VI) schedule of reinforcement, the reinforcement follows the first response after a varying interval of time has elapsed, the interval varying unpredictably from reinforcement to reinforcement (Ferster and Skinner, 1957). The value of the VI schedule denotes the average interval of time between the availability of reinforcement. The patterns of responding generated by variable-interval (VI) schedules in lower organisms are typified by those of the pigeon reported by Ferster and Skinner. This pattern is characterized by an extremely stable intermediate rate with almost no irregularities; i.e., the cumulative record approaches the appearance of a straight diagonal line, the slope of which depends upon the schedule value, the subject's deprivation, etc.

The cumulative records of a normal adult responding under various VI schedules (Holland, 1958a) are qualitatively identical to pigeon records. Perhaps the only unusual

feature of the human records is the rather high rate, which is more nearly like what one might expect of VR rather than VI responding. Holland also reported a slight increase in rate within sessions at VI 15 sec and VI 30 sec, but a slight decrease in rate within sessions at VI 1 min and VI 2 min. Between sessions but within subjects, a decrease in rate was observed as the VI temporal value was increased. Weiner (1962) reported the same decline in rates as average duration was increased from VI 1 min to VI 9 min. In addition, the imposition of point-loss response cost caused a decrease in rate relative to rates under the no-cost condition. No disruption of the stable pattern occurred, however, but only a change in slope.

Weiner (1965) reinforced button pressing in normal adults on a VI 10-sec schedule after a history of responding under either FR 40 or DRL 20 sec. Very little quantitative change and no qualitative change occurred in the pattern of responding of subjects with either type of history. Weiner noted that while the subjects with the FR history received nearly the maximum possible rate of reinforcement, the subjects with the DRL history received a considerably lower rate of reinforcement than they could have received.

Using a procedure similar to that reported by Weiner (1962, 1964a,b,c 1965), Kaufman, Baron, and Kopp (1966) reinforced normal adults' key pressing with points on a VI 1-min schedule. The subjects were given five different

sets of instructions prior to exposure to the experimental task. Group M (minimal) received virtually no instruction other than to accumulate points. Group R (response) was instructed as to the relationship between responses on the key signal lights and points. Group FI was given a description of the point contingency depicting it as an FI schedule. Groups VI and VR were given a description of the point contingency depicting it as a VI and VR schedule, respectively. The FI group showed a low-rate, spaced-responding pattern similar to that displayed by adult subjects who verbalized a temporal contingency in the study by Lippman and Meyer (1967). The M group displayed a pattern most like infrahuman responding under a VI schedule, i.e., an intermediate rate and steady pattern. The subjects in groups R and VI showed patterns similar to those reported by Holland (1958a) for subjects under VI 1 min. Subjects in group VR showed rates and patterns of responding very similar to those of retardates under VR 100 schedules (Orlando, 1961b). Thus, control exerted by instructions was well demonstrated.

Long _et al_. (1958) reinforced the button-press responses of normal children with trinkets and pennies under VI 0.5 min and VI 1-min schedules. Patterns of responding during early sessions were similar to those reported by Holland (1958a) for adults on comparable schedules. After three sessions, however, overall rates began to fall and pausing increased and grain became much more rough. This deterioration

tended to occur earlier where VI schedules were used which were constructed with few short inter-reinforcement intervals. The declining effectiveness of trinket and penny reinforcers in maintaining FR and FI responding in this study was described previously.

The performance of adult retardates under a VI 1-min schedule was generally similar to that reported for normal adults with very rough grain and some irregular pauses (Ellis et al., 1960). This same irregular pausing was reported in the cumulative records of adult inpatient psychotics responding under a VI 1-min schedule (Lindsley, 1960). Lindsley also reported much greater between-subject differences in response rates than that found among normals. The VI performance of the two autistic children reported by Ferster and DeMeyer (1961) was characterized by both low rates and irregular pauses.

Differential Reinforcement of Rates

Since this reviewer encountered no studies with human subjects employing a differential reinforcement of high-rates (DRH) schedule, only differential reinforcement of low rates (DRL) will be covered here. In a DRL schedule of reinforcement, reinforcement follows the first response after a pause in responding which equals or exceeds a fixed period of time. The value of the DRL schedule specifies the minimum duration of that pause. The investigations reporting the use of DRL schedules present data indicating excellent

schedule control; i.e., normal adult subjects rather quickly increase their pausing between responses until a high percentage of responses are reinforced and near maximum rate of reinforcement is received.

The general procedure used by Holland (1958a) has already been described. A DRL 30-sec schedule was programmed by following an observing response with pointer deflection only when at least 30 sec had elapsed since the last reinforcement was received.

In a pharmacological study of Dews and Morse (1958), a type of DRL schedule was used as a baseline for evaluating the effects of d-amphetamine. A second-order schedule was employed which formally would be denoted as a tand FR n (DRL p), which means reinforcement followed the nth response which satisfied the DRL p contingency. Two schedules were used: tand FR 100 (DRL 2.5 sec) and tand FR 10 (DRL 25 sec). During "training" the contingency was described, the schedule values were announced, and a sequence of clicks either 3.5 or 2.5 sec apart were presented to demonstrate the ideal spacing of responses. Not surprisingly, subjects emitted few early responses and performed at a nearly optimum level.

In the investigation conducted by Bruner and Revusky (1961), four response keys were available. Money reinforcement was programmed for responding on one key with interresponse times (IRTs) between 8.2 and 10.25 sec. Results

showed that subjects mediated this restricted interval by systematic responding on the non-reinforced keys, and indeed, after the experiment they reported the reinforcement contingencies as requiring complex patterns of responding using several keys. Similar "timing behavior" was reported by Kapostins (1963). The subjects were instructed merely to say words, some of which would be defined as correct and would be followed by a bell indicating money earned. The schedules employed were DRL 7, 17, 27, 37, and 47 sec. After the subjects began saying words, one was arbitrarily selected, its free-operant rate recorded, and reinforcement begun. Results revealed the use of chains of otherwise irrelevant words which separated the reinforced words in time and were thus differentially reinforced.

Multiple Schedules

In a multiple schedule (mult), two or more schedules of reinforcement are sequentially programmed, and a distinctive exteroceptive stimulus is paired with each. For example, in the presence of a red light, responding may be reinforced on an FR 40 schedule, and, in the presence of a green light, responding may be reinforced on a FI 3-min schedule (Holland, 1958a). Under this multiple schedule, Holland reported typical FR patterns of responding in the presence of the red light, i.e., high terminal response rates with pausing only after reinforcement. In the presence of the green light, the pattern of responding indicated an overall acceleration

of responding during the interval, but the "grain" showed the apparent influence of the FR history, i.e., within the scallop there were bursts and pauses rather than a gradual acceleration.

Dardano (1965), using normal adults as subjects and a vigilance task procedure similar to that of Holland, investigated the performance maintained by three different multiple schedules. In one two-ply multiple schedule, both components included a VI 6-min schedule, but the second component also had the additional requirement of a brief limited hold (LH) terminated by a bell (mult VI 6 VI 6 LH bell). The second multiple schedule was identical to the first except that an electric shock replaced the bell (mult VI 6 VI 6 LH shock). In the third multiple schedule, conditions like the second component of the previous schedule were alternated with a time out (TO) during which the subject was instructed to relax (mult VI 6 LH shock TO). In all cases the patterns of responding under the various VI schedules with and without limited-hold contingencies were characterized by rather steady rates with smooth grain and no pauses. Rates were lowest under the VI without LH and highest under VI 6 LH shock. Responding ceased under TO.

As previously mentioned, Weiner (1964b) alternated periods of signaled cost and no-cost conditions superimposed on FI 25-sec and extinction schedules. Behavior was rather effectively suppressed by the response-cost contingency under both the FI and extinction (EXT) schedule.

Scobie and Kaufman (1969) employed a four-component multiple schedule with VI 30-sec and VR 210 schedules of money reinforcement for adult's key-press behavior. In two components an intermittent schedule (VI 10 sec) of electrical shock was also imposed. The patterns of responding were similar in the non-punished components with higher rates being observed under VR 210 for subjects instructed as to the contingencies. Minimally instructed subjects showed steady, high rates in both components. In the punishment components all instructed subjects rapidly reduced response rates in the VI component while some showed increased and other decreased response rates in the VR component. Minimally instructed subjects showed suppression but no clear difference in suppression as a function of reinforcement schedule. Baron et al. (1969) investigated adult key-pressing behavior under a five-component multiple schedule of monetary reinforcement with different FI values in each component. The subjects who were instructed about the schedules showed an orderly progression of response rates and patterning as a function of the inter-reinforcement intervals. Minimally instructed subjects showed uniformly high rates in all components which generally persisted even after instruction was added.

Using normal children as subjects, Long (1959) initially exposed them to a mult FI FR 10 with the FI value being either 1.5 or 2.0 min. When no indication of differential

schedule control was observed, the classes of reinforcement (penny plus trinket or trinket alone) were made different for the two components. The control produced here most closely resembled that found under "mixed" schedules; i.e., some change in pattern occurred after the first reinforcement following a schedule change. Ratio components were characterized by responding through the interval or pauses followed by a rapid transition to a high rate. Greater evidence of schedule control was achieved when a Lindsley, plunger-type manipulandum replaced the previously used button. Long (1962) reported good schedule control with normal children under mult FR EXT, mult DRO FR and mult DRL FR where FR values were either 5 or 10, DRO values were from 2 to 32 sec and DRL values were from 2 to 16 sec. Although some evidence for differential schedule control was shown in some subjects under mult FI 1.5 min FR 10, in most cases remedial procedures were necessary to achieve stimulus control. These procedures included presenting FRs in blocks, increasing the value of the FR schedules, adding a DRL requirement temporarily to the FI component, or temporarily replacing the FI schedule with a DRL contingency. Adding an external clock to the FI component of the mult FI FR produced differential patterns of responding. This difference was particularly evident for subjects whose exposure to the mult FI FR with clock was preceded by exposure to mult FR EXT or else no previous experimental

history; i.e., the subject was naive. The improvement in control achieved by these various techniques was accomplished by reducing the response rate during the FI components.

O'Brien (1968) investigated the behavior of retarded children under mult VI EXT schedules. Five-minute periods of exposure to the VI or EXT schedules were presented in a random order. Besides getting characteristic smooth, steady rates in the VI components and little responding in extinction, response rates in VI periods following EXT periods were increased over response rates in VI periods following other VI periods. This contrast effect was observed to be transitory, however, and was not apparent by the tenth session. Waite and Osborne (1972), employing mult VI VI and mult VI EXT schedules with each normal child subject, reported sustained contrast effect. When the schedule in one component was changed from VI to EXT, an increase in response rate in the unchanged VI component was observed which persisted from 9 to 15 sessions. A similar decrease in response rate in the unchanged VI component was observed when the schedule in the other component was changed from EXT to VI. The changes in response rate in the unchanged VI schedule component did not affect the characteristic VI pattern of responding, but only could be seen as changes in the slope of the cumulative record.

Bijou and Orlando (1961) described a procedure for the rapid development of multiple-schedule performance in

retarded children. In this procedure stage one terminated when subjects responded at a rate of 20 responses per minute or higher on FI 15 sec. Failure to meet this criterion resulted in exposure to an increasing ratio schedule designed to increase response rate. The description of stage two was unclear as to whether subjects were exposed to a chain DRO CRF or chain DRL CRF, with increasing temporal requirements of the DRO or DRL schedule. If the latency of responding upon presentation of the stimulus associated with CRF remained short, and pauses of 30 sec or more occurred in the presence of the other stimulus, stage three was begun. Stage three merely repeated stage one, with the same criterion and remedial procedure. In stage four, the subject was exposed to a two-ply multiple schedule with one schedule being extinction and the other being an FI of 1 min duration or less or a ratio of 50 or less. The data shown for subjects shaped using this technique depicted rather typical FR and VR patterns of responding together with pauses in the presence of S-delta. Under FI schedules, responding was maintained throughout the interval, but stimulus control was well demonstrated. The steady pattern generated by a VI 0.5-min schedule was typical, but the rate was unusually low for a VI schedule of that value. The stimulus control with the schedule combination was not well demonstrated as no extended periods of the extinction component were depicted. Whatever advantages this procedure may have would relate to the

rather quick development of multiple-schedule stimulus control as behavior similar to terminal performance was achieved by the end of the first session. This statement must be tentative, however, as session length was never given and appears to have been variable.

Attempts by Ferster and DeMeyer (1961) to bring the responding of autistic children under the control of mult FR VI schedules were unsuccessful with responding in both components being characterized by high rates and post reinforcement pauses.

Chain and Tandem Schedules of Reinforcement

A chain is similar to a multiple schedule except that responding in the presence of one stimulus produces not primary reinforcement, but a second stimulus, and responding in the presence of that second stimulus produces reinforcement. Tandem schedules are like chain schedules with no exteroceptive stimulus paired with each component. Long (1963) investigated human performance under chain and tandem schedules of positive reinforcement with normal children serving as subjects. Chain DRL FR and chain DRO FR schedules almost always produced strong schedule and stimulus control, but chain FI FR rarely did if additional techniques were not used. Control was improved with chain FI FR schedules if the FR component was increased in size, if schedule and stimulus control was first established with chain DRL FR or chain DRO FR schedules before shifting to the chain FI FR, or

if an external clock was added to the FI component. Tandem (tand) FI FR schedules never produced regular or repeatable patterns of responding when additional procedures were not used. Response patterns resembling those of chain FI FR were produced by tand FI FR schedules if an external clock was added to the FI component, or if control had been previously established by tand DRO FR.

Concurrent Operants

Ferster and Skinner (1957, p. 724) defined concurrent operants as "Two or more responses, of different topography at least with respect to locus, capable of being executed with little mutual interference at the same time or in rapid alternation, under the control of separate programming devices." Concurrent (conc) schedules will thus refer to two or more schedules operating simultaneously but independently with respect to two or more concurrent operants.

Schroeder and Holland (1969) conditioned macrosaccadic eye movements of normal adults to two areas of a four-dial display employing conc VI VI schedules of signals. Reinforcers (signals) were delivered to the two right-hand dials according to one schedule and delivered to the left-hand dials according to another. Schedule values ranged from VI 9 sec to VI 60 sec, and sessions were conducted both with and without changeover delays. In the presence of a changeover delay, subjects matched relative eye-movement rates to relative reinforcement rates on each schedule.

Rate of crossover eye movements, with a changeover delay in effect, was also inversely related to the difference in reinforcement rates programmed on the concurrent schedules.

Sanders (1969) reported normal adults' performance on a button-pushing task under conc FI FR schedules of monetary reinforcement. Manipulations of the FR requirement from 50 to 1,000 responses while holding the FI schedule at either a 3- or 9-min duration produced the following effect: When the fixed ratio was small, more fixed-interval responding occurred per interval than when the fixed ratio was large. Bursts of responding under the FI schedule were often observed after reinforcement under the FR schedule, but little post reinforcement pausing or ratio strain was observed.

Twenty-four normal adult subjects were studied for 10 one-hour sessions to determine whether human observer's visual monitoring of individual meters in a complex display could be differentially controlled by concurrent scheduling of signals (reinforcers) (Frazier and Bitetto, 1969). All of the subjects were exposed to conc FI, VI, and DRL schedules. The subjects were instructed only to detect as many signals as possible. Schedule values included FI 30 sec and 60 sec, VI 30 sec and 60 sec, DRL 7.5 sec and 10 sec, and FR 20 and 30. A limited hold of 15 sec was in effect for detection of all signals. No changeover delay was employed. Results indicated that observing responses to individual meters corresponded to the temporal patterns of responding observed under those schedules with lower organisms only for

the group of subjects exposed to an FR schedule in one component. The group who was exposed to a VI schedule in combination with an FI and DRL, tended to exhibit the same pattern of observing responses to all three meters during any given session. Schedule control like that observed with infrahuman organisms was produced when additional subjects were given instructions as to the reinforcement contingencies, feedback in training sessions as to missed signals, and an extended number of sessions under the conc FI VI DRL schedules.

Poppen (1972) studied the performance of normal adults on a lever-pressing task for money under conc FI 1 min DRL 20 sec and under conc FI 1 min FR 100 schedules of reinforcement. All subjects were exposed to both concurrent schedules. The patterns of responding generated in the DRL and FR components were similar to those reported in animals and other human studies, i.e., very low-rate, spaced responding under DRL and high-rate responding under FR. The FI performance when the concurrent schedule was FR 100 was characterized by long post-reinforcement pauses, the latency of the first response usually exceeding the 1-min FI requirement. When the concurrent schedule was DRL 20 sec, the FI performance was characterized by high rates with no post-reinforcement pause. These results contrast with those reported by Weiner (1964c) for performance under FI schedules following a history under either FR or DRL schedules.

Favell and Favell (1972) employed conc VI 15 sec VI 15 sec EXT EXT and conc VR 4 VR 4 EXT EXT with normal children in a matching-to-sample procedure. There were four possible responses, with correct matches possible on either the color or form dimension. Either correct match produced token reinforcers (exchangeable for money) according to the VI or VR schedules. Every match on one dimension also produced a stimulus complex which preceded every token delivery (the paired stimulus) and every match on the other dimension produced a stimulus which never occurred closely in time-to-token delivery (the unpaired stimulus). The unpaired stimulus presentation was omitted of course for those matches for which token reinforcement was also programmed. Mismatches produced a brief blackout condition. Three of the five subjects responded primarily to the dimension that was associated with the paired stimulus.

The three following investigations all involved some type of discrimination task with two available responses, with extinction always programmed for at least one of the responses. The subjects in all three of these experiments were retarded children. Barrett and Lindsley (1962) used a procedure in which responses on one of two levers were reinforced on an FR schedule in the presence of light above the manipulandum,and extinction was programmed when the light was off. Extinction was programmed for both light-on and light-off conditions on the other manipulandum. The light

was always on over one manipulandum but never both. The schedule was thus conc mult FR EXT mult EXT EXT. Results indicated a great deal of between-session and within-session variability and extremely slow acquisition of stimulus control. The higher the FR schedule value (up to 10), the poorer the stimulus control. Orlando (1961a) used a procedure similar to that described above with the schedules being conc mult CRF EXT mult CRF EXT where EXT components are of 40-sec duration, and the stimulus associated with the CRF component was terminated after one reinforcement. This is programmed like an FI 40-sec schedule with a stimulus indicating when a reinforcement is "set up." Ten of the twelve subjects in this study responded with a latency of 5 sec or less in the CRF component on 90% or more of the component presentations, and paused for 30 sec or more on over 80% of the EXT component presentations. Orlando (1961b) employed a conc mult VR 100 EXT VR 100 EXT where at any point in time the schedules programmed for the two available responses were never identical. Under terminal performance, 99% of responses occurred during the VR components at high steady rates with virtually no pauses.

Summary

Performance was obtained from normal and clinical subject populations which closely resembled that of lower organisms on comparable FR, VR, and VI schedules. The atypical patterns which were obtained were almost exclusively

in clinical populations and were characterized by unusual pausing, high between-subject variability, poor stimulus control, and, in some subjects, inability of the experimenter to maintain subjects' responding.

Performance under FI schedules, whether singly programmed or in multiple, chain, or concurrent schedules, was rather variable. The following is a list of sources of this variability, drawn from the studies reviewed, which affect patterns of responding under FI schedules.

1. Perhaps the single most important variable is the subject's experimental history.

2. A variable related to experimental history is that of instructions.

3. Concurrent schedules of reinforcement were shown to affect the pattern of FI responding in a different manner than a history of those same schedules.

4. Interval duration may well be a relevant variable in that short intervals are particularly likely to maintain continuous responding.

5. Punishment of responding, for example by point loss, was shown to differentially affect the pattern of responding.

6. A variable which may be related to punishment of responding is the force required to emit the response.

7. A variable suggested from data with DRL as well as FI schedules is collateral timing or time-mediating behavior of the subject.

8. The final variable is an external, time-mediating stimulus, e.g., a clock.

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Thomas Robert Waddell was born on May 7, 1945, in Florence, South Carolina. He attended public school in Melbourne, Florida, and graduated from Melbourne High School in June, 1963. In September, 1963, he enrolled at the University of Florida. During the summers of 1963 to 1965 he did road construction and maintenance work for Brevard County, District 5. During the summers of 1966 and 1967, he worked for the Boeing Company on the Lunar Orbiter Space Program. In April, 1967, he received the Bachelor of Arts degree from the University of Florida, and in September of that year entered graduate school in the Department of Psychology. There, during his first three years in graduate school, he was the recipient of an NDEA Title IV Fellowship. He received the Master of Arts degree in June, 1970. From September, 1971, until August, 1972, he was a clinical psychology intern at the University of Mississippi Medical School in Jackson, Mississippi.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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