EFFECTS OF INSTRUCTIONAL CONSTRAINTS ON HUMAN FIXED-INTERVAL PERFORMANCE

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Several groups of human subjects were exposed to a variety of experimental conditions involving a fixed-interval 27-second schedule of reinforcement in compound with instructions to constrain in the number of responses within the interreinforcement interval and/or the duration of the experimental session. One group was further exposed to a contingency involving the placement of responses within the IRI. A diversity of patterns of performance was observed, including those typically associated with animal subjects exposed to FI schedules. Generally, the imposition of instructions to minimize session duration reduced post-reinforcement pausing and increased overall reinforcement density from those levels obtained with only instructions to expend a given number of responses per reinforcer. The results are seen to underscore the sensitivity of human fixed-interval performance and the contribution of extra-experimental contingencies.

Key words: instructions, fixed-interval schedule, response constraint, time constraint, pause-respond pattern, door-pull response, humans

With fixed-interval (FI) schedules of reinforcement, the delivery of a reinforcer is contingent upon the occurrence of a response, provided that a fixed amount of time has elapsed since the previous delivery. Early analyses of human behavior under FI contingencies showed performance to be of two types: (i) an extremely high rate of response with little or no postreinforcement pause (Leander, Lippman, & Meyer, 1968; Lippman & Meyer, 1967; Weiner, 1965), or (ii) an extremely low rate of responding with one or a few responses occurring close to reinforcer delivery (Baron, Kaufman, & Stauber, 1969; Bullock, 1960; Matthews, Shimoff, Catania, & Sagvolden, 1977).

These performances are unlike those typically produced by animals under similar FI contingencies. The behavior of animal subjects has often been described as evincing either "scalloped" or "break-and-run" patterns when reference is made to the cumulative record. Scalloped patterns of responding (Ferster &

Skinner, 1957) are characterized by a pause at the beginning of each interreinforcement interval (IRI) followed by a gradual acceleration of responding until the reinforcer is delivered. Break-and-run patterns (Cumming & Schoenfeld, 1958; Schneider, 1969), on the other hand, are typified by an abrupt transition from little or no responding to a high and relatively constant response rate. Whether this type of pattern is actually distinct from scalloping has been called into question by subsequent analysts (Branch & Gollub, 1974; Dews, 1979; Lowe & Harzem, 1977). The oscillatory, "pause-respond" pattern characteristic of animal performance—whether it be of the scalloping or break-and-run varieties—is often considered indicative of sensitivity to the temporal structure of the FI contingency. By contrast, such patterns in human performance have persistently eluded researchers (e.g., Baron et al., 1969; Bullock, 1960; Laties & Weiss, 1963; Matthews et al., 1977; Weiner, 1965, 1969).

Recently, Buskist, Miller, and Bennett (1980) exposed human subjects to FI contingencies designed to be more similar to those employed in animal research. Subjects were placed in front of a modified vending machine that had been programmed to operate in essentially the same manner as the single-manipulandum devices used with animals: food reinforcers could be obtained by pulling on one of

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the machine's doors. Among the response patterns subjects displayed was that of scalloping. The earlier-described patterns involving high, invariant response rates and very low rates were also obtained.

A motivational consideration may be instructive to the issue of discrepancies in animal and human FI performance. For the food-deprived organism, the within-session imperative is particularly clear: adapt or remain hungry. The pause-respond pattern of behavior that typically emerges can be construed as an adaptive blending of temporal and behavioral resources (time devoted to responding and response output, respectively) in the acquisition of food. According to this view, the structure of the experimental situation (i.e., food deprivation, schedule contingencies, etc.) constrains the organism to expend its time and activity in a particular manner in order to obtain reinforcement. The gradually accelerating expenditure of responses prior to reinforcement has the effect of minimizing the IRI and thus maximizes the overall frequency of reward in the situation. Is there any reason to suspect that humans should distribute the same resources in a similar manner? The variability in the available data strongly suggests a negative answer (Baron, *et al.*, 1969; Bullock, 1960; Buskist *et al.*, 1980; Laties & Weiss, 1963; Leander *et al.*, 1968; Matthews *et al.*, 1977; Weiner, 1964, 1965, 1969). Low-rate responders appear to conserve responses and thus expend more time than necessary to complete session requirements; high-rate responders appear to conserve the time spent in each session but at the expense of a larger number of responses. Those human subjects who emit a pause-respond pattern of activity when exposed to FI schedules appear to expend both resources in a manner similar to animals. The pause-respond pattern insures a reinforcement density on a par with that produced by high constant rates of response without requiring the same overall levels of response output. Alternatively, it often produces higher reinforcement densities than those produced by low rates of response and, concomitantly, may not require the elaborate strategies for timing (e.g. counting) frequently associated with low-rate response patterns and which may be relatively difficult to maintain.

Accordingly, an alternative method for the production of pause-respond patterns of be-

havior in humans might lie in placing differential emphasis on their temporal and behavioral resources. The present experiment was designed to test this notion by employing various instructional directives vis-à-vis response output and time spent in the session. Such an approach seeks to underscore the sensitivity of human subjects to experimental contingencies involving the allocation of temporal and behavioral resources.

METHOD

Subjects

Thirty-five Brigham Young University students—19 females and 16 males—were recruited to serve. Only two subjects reported previous experience with behavioral research.

Apparatus

A slightly modified Visi-Vend vending machine (The Vendo Company; Monument, Colorado) was housed inside a small darkened room. A white plastic panel (12.7 by 78.7 cm) with the words "Cold Food" printed on it was located at the top of the machine and was transilluminated during each IRI by two 75-W light bulbs. Responses consisted of pulls on a single door (10.2 by 15.2 cm) that was located directly below the center of the overhead sign at a distance of 15.2 cm. This door was the second from the top in a series of 10 such doors that were arranged vertically. The door contained a clear Plexiglas panel and was always illuminated by a 5-W light bulb located directly above the panel at its interior. During IRIs the door was essentially "locked"; pulls on the door opened the door approximately 2 cm. Only after the appropriate response could the door be completely opened and the reinforcer accessed. Through the panel the subjects could view a 3-dl paper cup which contained the reinforcer—mixed nuts, pretzels, raisins, or chocolate chips.

All experimental conditions and data collection were controlled by an SMS-12 microprocessor which utilized the SKED software system.

Procedure

Experimental sessions were conducted at the same time daily, Monday through Friday. Prior to the beginning of the experiment, subjects were given their choice of reinforcer. The

snack item chosen was then used as the reinforcer for that subject throughout the experiment.

At the beginning of the initial session, each subject was read the following general instructions:

The snack item behind this door can be obtained by pulling on the corresponding door handle. Once the snack has been obtained, close the door and eat the snack immediately. The overhead light will remain off when the session is over.

Subjects could sit or stand in front of the vending machine and were further instructed that they could pull at the door with either hand. Any questions from the subjects regarding the experiment were answered by referring them to a typed set of instructions (same as above) attached to the front of the machine at eye level. No watches were worn by subjects during the sessions, nor was there a clock in the experimental room.

The lighting of the overhead panel initiated each session. Once the response requirement for opening the door was met, the overhead panel would darken for a 4-sec period, during which the door could be opened by the subject and the food removed. At the end of this period, the overhead panel was again illuminated. The closing of the door engaged a motor which rotated the metal tray upon which food cups were located. This tray was divided into separate compartments, each of which contained a food cup. Following reinforcement, the motor would rotate the tray until the next cup was visible behind the door. Session termination came after 20 reinforcements were delivered and was marked by the permanent darkening of the overhead panel.

All subjects were exposed to an FI 27-sec schedule for at least eight sessions and until responding had shown stability over four consecutive sessions. Typically, human responding on FI schedules stabilizes rapidly and is insensitive to further experimental manipulation (Weiner, 1965, 1969). The slope of the cumulative record was the basis for determining stability.

Prior to the beginning of the experiment, the subjects were randomly assigned to seven groups (five subjects per group). The groups received the following sets of specialized instructions:

Group NO-I No further instructions were given to this group.

Group NO-T/10 "You are to use 7-10 door pulls to obtain each snack item."

Group T/10 "You are to use 7-10 door pulls to obtain each snack item and are to complete each session (that is, obtain 20 snack items) in 9-min and 10-sec or less."

Group T/10/MOD "You are to use 7-10 door pulls to obtain each snack item and are to complete each session (that is, obtain 20 snack items) in 9-min and 10-sec or less."

(This group was given the same instructions as Group T/10 but was placed on a slightly modified FI 27-sec schedule. If a response was made before 13.5 sec had elapsed during the IRI, then the first response after the 27-sec interval had elapsed would darken the overhead light but the door would not open. Thus subjects in this group had to wait at least 13.5-sec before responding in order to obtain reinforcement when the 27-sec interval had elapsed. Subjects were not informed of this contingency.)

Group T "You are to complete each session (that is, obtain 20 snack items) in 9-min and 10-sec or less."

Group NO-T/23 a "You are to use 20-23 door pulls to obtain each snack item."

Group T/23 "You are to use 20-23 door pulls to obtain each snack item and are to complete each session (that is, obtain 20 snack items) in 9-min and 10-sec or less."

Nine minutes was the minimum amount of time necessary to obtain 20 reinforcers on this FI 27-sec schedule (excluding the 4-sec reinforcement periods). The instruction to com-

plete the session within 9 min and 10 sec was intended to prompt session completion within the shortest possible time. Subjects in the four groups where the instructions involved session duration were informed prior to each session of the actual duration (with reinforcement time omitted) of the previous session. If subjects in groups given a response requirement exceeded their response allotment within an interval, reinforcement was not omitted, but subjects were cautioned prior to the next session to stay within the prescribed range.

Subjects were not dismissed from the experiment until they had met the requirement of their respective groups, and their performances had stabilized. After the final session was completed, each subject was interviewed by the experimenter and informed as to the purpose of the research.

RESULTS

Figures 1a and 1b show representative cumulative records for subjects in each group after responding had stabilized. Numbers in parentheses represent the number of subjects in each group who responded in a manner shown on the corresponding cumulative record.

All subjects in Group NO-I responded at an extremely low rate following a lengthy postreinforcement pause (PRP). This pattern is typical of many human subjects exposed to FI schedules (see, e.g., Buskist *et al.*, 1980, and Matthews *et al.*, 1977). Subjects instructed only to use 7-10 responses per reinforcer (Group NO-T/10) exhibited two patterns of responding. Three subjects pulled the door at a low steady rate following brief PRPs, while the two other subjects responded with a "break-run-break" pattern; i.e., following a moderately lengthy PRP, there was a burst of responding that was followed by another pause prior to responding that produced reinforcement. Typically, these subjects emitted at least six responses during the burst, then waited to emit the remaining one to four responses near the end of the IRI. All subjects in Group T/10/MOD pulled at the door in a break-and-run fashion shown by some animals on short FI schedules (Cumming & Schoenfeld, 1958; Schneider, 1969). Subjects in Group T/10 manifested two forms of responding: either a "run-and-break" pattern characterized by a brief burst of responding immediately following reinforcement after which the subject would wait

before final responding, or a break-and-run pattern similar to that exhibited by T/10/MOD subjects, except for a shorter PRP. Subjects constrained with only the 9-min and 10-sec requirement (Group T) also exhibited one of two forms of responding: either a moderate steady rate following a brief PRP or an extremely high rate of responding following short PRPs.

Three subjects in Group NO-T/23 responded in a pause-respond fashion in which short PRPs were followed by gradually accelerating responding that slightly decreased near the delivery of reinforcement. The two other subjects in this group responded in a run-and-break manner similar to the one subject in Group T/10. These subjects emitted the majority of the required number of responses early in the IRI and the remaining responses at its end. Subjects constrained by both the time and 20-23 response requirements (Group

Fig. 1a. Cumulative records obtained from six subjects representative of the responding of Groups NO-I, NO-T/10, T/10/MOD, and T/10. The records are from the final session of the experiment. Numbers in parentheses represent the number of subjects in each group whose response patterns were similar to the cumulative record shown.

Fig. 1b. Cumulative records obtained for six subjects representative of the responding of Groups T, NO-T/23, and T/23. The records are from the final session of the experiment. Numbers in parentheses represent the number of subjects in each group whose response patterns are similar to the cumulative record shown.

T/23) showed two patterns of responding: either a moderate steady rate of responding similar to that of one subject in Group T or a negatively accelerating response rate following little or no PRP. Responding of this latter variety resembled that of two subjects in Group NO-T/23 except that responding gradually tapered off near the end of the IRI rather than abruptly terminating.

Table 1 shows individual data for all subjects in forms of PRP duration, response rate, and IRI length during the last session of the

experiment. Also given for each subject is the session number during which behavior was first assessed to be stable. Entries for PRP and IRI durations are means for each subject over the last session while response rates were calculated by dividing a subject's total responses in the session by the total session duration.

Group NO-I subjects, who received no further instructions, had the longest PRP durations while Group T and T/23 subjects had the shortest PRPs. Four subjects in Group T/10 had moderately long PRPs while the remaining subject (JC) had a very brief pause after reinforcement. NO-T/10 subjects also showed variability in PRP durations with three subjects pausing briefly after reinforcement and the remaining two subjects waiting moderately long before an initial response. NO-T/23 subjects manifested uniformly brief PRPs although longer in duration than their time constrained counterparts in Group T/23. All T/10/MOD subjects waited before emitting an initial response in accordance with the 13.5-sec pause contingency.

Group NO-I subjects had uniformly low response rates while Group T subjects emitted extremely high rates of response. Subjects given the 7-10 response constraint, regardless of the presence of other constraints and/or contingences (Groups T/10, NO-T/10, and T/10/MOD) emitted uniformly similar rates of responding, as did subjects given the larger response constraints (Groups T/23 and NO-T/23) although these latter two groups responded at a much higher rate.

NO-I subjects generally had the longest IRI durations (except Subject VA in Group NO-T/23). Subjects in groups without a time constraint generally had slightly longer IRI values than did groups under a time requirement (Groups T, T/10, T/23, and T/10/MOD).

During postexperimental debriefing, the subjects all concluded that the experiment was boring. Most NO-I subjects reported that obtaining the snack item (reinforcer) was time-based and only required one response. Moreover, most of the subjects in this group adopted either a counting or an alternative tempo-setting approach (singing, reciting poetry, etc.) with which to separate responses. Group NO-T/10 subjects also reported that obtaining the snack was time-based and either distributed door-pulls over the IRI using a fixed tempo or counted to a certain number

before an initial response. Group T/10/MOD subjects also reported counting to a certain number before pulling on the door. They also indicated that if they counted too fast before making their first response, they would finish too soon and the door would not open. Group T/10 subjects reported that it was necessary to place their 7th-10th responses close to the point when they first guessed that the door could be opened. Most of the Group T subjects reported that while it seemed that the time it took to get the door open from one reinforcement to the next required a large number of pulls, the exact number did not seem to be important. Group NO-T/23 sub-

jects reported that the experiment was time-based, but continued to pull at the door in order to exhaust the number of required responses. Subjects in this group also reported counting strategies similar to Group NO-T/10 subjects. Subjects in Group T/23 indicated that they counted both time and the number of door-pulls so as to assure that the 20-23rd pull would coincide with the earliest time at which the snack item became available.

DISCUSSION

These data show that when human FI performance is modified by instructions involving

Table 1

Individual data for each subject in each group obtained during the final session of the experiment. Entries for PRP and IRI columns are means for each subject over the 20 reinforcements in the last session. Response rates were calculated by dividing a subject's total responses in the session by total session duration. Entries in the final column represent the first session after which little variability in the slope of the cumulative record was apparent.

<i>Group</i>	<i>Subject</i>	<i>PRP (Sec)</i>	<i>Response Rate (Responses/Min)</i>	<i>IRI (Sec)</i>	<i>Sessions to Stability</i>
NO-I	TK	29.20	2.34	29.50	1
	SD	27.70	2.64	32.05	4
	JR	37.90	1.80	38.80	7
	KA	34.40	1.80	38.35	3
	CB	29.25	3.48	30.35	2
NO-T/10	SM	16.45	15.60	29.00	2
	LA	11.10	18.00	28.95	2
	MT	4.70	14.40	28.30	2
	EN	1.55	16.20	29.35	3
	AK	5.25	16.80	29.05	4
T/10/MOD	EK	16.10	16.80	27.15	5
	NS	20.60	16.80	27.10	6
	KE	16.65	15.60	28.10	3
	MA	18.70	18.60	27.60	5
	RA	24.65	16.80	27.05	3
T/10	TO	20.40	16.80	27.55	12
	RH	10.15	21.00	27.70	3
	JCI	13.70	19.20	27.85	4
	JC	0.15	18.60	27.20	7
	BW	17.40	17.40	27.80	3
T	LN	1.50	185.00	27.05	4
	VB	0.15	202.80	27.05	2
	AW	0.20	216.00	27.00	6
	BB	0.10	279.00	27.00	1
	MM	2.10	29.40	27.30	6
NO-T/23	CB	4.35	41.40	30.65	2
	VA	3.75	38.40	40.00	2
	DH	5.45	45.00	28.50	7
	CA	3.90	40.80	30.55	2
	RM	4.20	48.00	28.40	2
T/23	TP	0.05	46.20	27.70	2
	JP	0.15	49.20	27.30	1
	BP	0.25	48.00	27.40	3
	CW	0.05	45.60	27.35	4
	FS	0.20	45.60	27.70	4

time or response requirements or both, a variety of response patterns emerges. Subjects in Group T and NO-I showed response patterns (see Figures 1a and 1b) similar to those found in previous research: performance was characterized by either high, relatively constant response rates (cf. Leander et al., 1968; Lippman & Meyer, 1967; Weiner, 1965) or very low response rates (cf. Baron et al., 1969; Bullock, 1960; Matthews et al., 1977).

As suggested at an earlier point, under normal FI contingencies high invariant response rates could be considered reflective of response patterns which minimize time spent in a session. Conversely, subjects who emit low rates of responding could be viewed as minimizing the expenditure of responses with no premium on minimal session duration. The data shown in Table 1 support this view. Generally, Group NO-I subjects had the longest IRIs, while those for Group T subjects were shortest. That such a trend played a role in the performances of subjects in Groups NO-I and T is further suggested by their verbal reports. Group NO-I subjects uniformly reported that the experiment involved waiting for a specific amount of time and that only one response was necessary to obtain the reinforcer. Subjects emitted more than one response per reinforcement only when inaccurate estimation of the passage of time (e.g., by counting or singing) caused them to respond at a point prior to the completion of the interval. Subjects in Group T, on the other hand, reported that the interval between reinforcements was "about the same from time to time" and that continuous responding was essential, though the number of responses required for reinforcement was variable. Apparently, the instruction to complete each session with a near-minimal span of time overrode any tendency toward the waiting patterns of subjects in Group NO-I. In fact, subjects in Group T responded similarly to those in a study by Weiner (1969), where subjects had a history of responding on a fixed-ratio schedule prior to being exposed to FI contingencies.

The responding of subjects in Groups NO-T/10 and NO-T/23 shared several consistencies. Three subjects in each group responded at a fairly constant rate throughout the interval following a brief PRP although the three NO-T/23 subjects had slightly longer PRPs. The remaining two NO-T/23 subjects paused very briefly following reinforcement, then re-

sponded at a high rate, and paused again before obtaining reinforcement. Such a pattern was also present among the final two subjects in Group NO-T/10 except for a longer PRP. Subjects in both groups reported an impression that the passage of time was important for reinforcement delivery and that it was necessary to "save some of the responses for the end". Table 1 indicates that IRIs for the two groups were longer than any other group, except those for Group NO-I. Thus, the addition of instructions stipulating a response requirement effected an increase in overall reinforcement density (the reciprocal of the IRI) from that obtained without such instructions (Group NO-I); however, the density fell short of that produced by subjects whose instructions urged a minimizing of session duration as well as (in some cases) a specified response output.

Although the verbal reports for Groups T/10 and T/23 indicated that subjects were sensitive to the amount of time required before reinforcement would occur, there appear to have been alternate approaches for spending required responses prior to the one responsible for obtaining the reinforcer. Four subjects in Group T/10 emitted the bulk of their allotted responses late in the interval while the other subject responded at a very high rate immediately after reinforcement, paused, and then emitted the one or two responses necessary to procure reinforcement. Two subjects in Group T/23 responded in a manner similar to the latter subject, except that subjects' responding decreased more gradually rather than stopping altogether in the latter part of the IRI. The other three T/23 subjects responded at a fairly constant rate throughout the entire IRI (cf. subjects' performances in Group 9:10 and three subjects' performance in Group NO-T/20-23).

All subjects in Group T/10/MOD responded in uniform fashion, pausing moderately after reinforcement, then gradually increasing responding until delivery of the reinforcer. A similar break-and-run pattern occurred for four subjects in Group T/10. Subjects' sensitivity to the no-respond constraint during the first half of the interval was also revealed in their verbal reports.

While Groups T/10, NO-T/10, T/23, and NO-T/23 exhibited variability in performance, Groups T, NO-I, and T/10/MOD

manifested rather consistent response patterns. The performance of Groups T and NO-I coincides with results from most previous experiments with human FI performance (either high and low response rates respectively; see, e.g., Baron *et al.*, 1969; Leander *et al.*, 1968) while T/10/MOD subjects' performances approximated those typical of animals under FI contingencies (see, e.g., Lowe, Harzem, & Bagshaw, 1978). NO-I subjects were uninformed about particular contingencies and T subjects were instructed only to complete the session in short order. Group T/10/MOD however, was instructed as to the time and response constraints but faced an additional unmentioned constraint absent from all other groups. In fact, failure to meet the 13.5-pause contingency actually resulted in loss of reinforcers while for Groups T/10, NO-T/10, T/23, NO-T/23, instructions did not pertain to the delivery of reinforcement.

Taken together, these results emphasize the sensitivity of human subjects to FI contingencies in compound with instructional constraints on the allocation of temporal and/or behavioral resources. This is important in light of the fact that most investigators of human FI performance have hinted that humans are generally insensitive to this type of schedule, i.e., human performance generally fails to replicate the patterns of responding which characterize animal subjects (see, e.g., Baron *et al.*, 1969; Bullock, 1960; Laties & Weiss, 1963; Lowe & Harzem, 1977; Matthews *et al.*, 1977; Weiner, 1965, 1969). While it is conceded that virtually any pattern of performance could be produced by means of instruction, we do not consider the patterns that emerged in this experiment to have been completely arbitrary. Nor do we consider them to have been completely fashioned by the mix of instructional and scheduled contingencies. There was still substantial opportunity for extra-experimental contingencies to have exerted influence. Furthermore, we do not maintain that our instructional protocols produced motivational states isomorphic to those experienced by hungry pigeons or rats. Rather, our aim was to show that the use of instruction-induced constraints on within-session expenditures of time and number of responses within an interval is correlated with distinctive patterns of action. That subjects within a group often exhibited more than one pattern and that these

patterns, in some cases, approximated those traditionally associated with food-deprived animals, suggests that FI performance, whether human or animal, should be viewed as the product of sensitivity not only to those contingencies imposed during the experimental sessions but also to those within which the session is embedded.

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