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INTERREINFORCEMENT TIME, WORK TIME, AND THE POSTREINFORCEMENT PAUSE

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Six rats were trained with food deliveries contingent upon their pressing a lever and holding it down for fixed, cumulative durations. Hold requirements were varied from 7.5 seconds to 120 seconds. Lever holding was maintained reliably at hold requirements as long as 30 seconds to 105 seconds for different rats. At longer hold requirements, lever holding was erratic and tended to occur only early in sessions. At shorter and intermediate requirements, the patterns of lever holding resembled those of responding under fixed-ratio schedules for discrete responses, with breaks in responding immediately after reinforcement alternating with relatively continuous lever holding until the next reinforcement. At longer hold requirements, postpause lever holding frequently was interrupted with additional pauses. The duration of postreinforcement pauses increased linearly with the scheduled hold requirement. However, for five of six rats, the hold requirement, which represents the actual time spent lever holding per reinforcer, accounted for somewhat less variance in pause duration than did interreinforcement time.

Key words: postreinforcement pause, interreinforcement time, work time, continuous response, lever holding, rats

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Performance under schedules that provide reinforcement periodically, such as fixed-interval (FI) and fixed-ratio (FR) schedules, is characterized by a period of time immediately following reinforcement during which no responding occurs. The duration of this postreinforcement pause increases monotonically as the fixed interval (e.g., Harzem, 1969; Innis & Staddon, 1971; Lowe & Harzem, 1977; Schneider, 1969; Shull, 1970, 1971; Skinner, 1938; Wilson, 1954) or fixed ratio (e.g., Felton & Lyon, 1966; Powell, 1968) is increased.

Findings of Killeen (1969), Nevin (1973), and Rider (1980) suggest that pause duration may be controlled similarly by the average time between reinforcers for both FI and FR schedules. Killeen (1969) found that pause durations were approximately the same under FR schedules and yoked-interval schedules in which interreinforcement times matched those obtained from the FR schedules. Nevin (1973) analyzed data obtained by Berryman and Nevin (1962) and found that pause duration was a linear function of the average interreinforcement times obtained under FI, FR, and interlocking FI FR schedules. Rider (1980) found that pause duration was linearly related to average interreinforcement times obtained under alternative FI FR schedules over a broad range of schedule parameters.

The good linear fit between pause duration and interreinforcement time across simple FI and FR schedules and complex interlocking and alternative schedules raises the possibility that interreinforcement time controls pausing independently of the particular schedule of reinforcement. However, in a direct comparison of FI and FR schedules with comparable interreinforcement times, Capehart, Eckerman, Guilkey, and Shull (1980) found that the relationship between pausing and interreinforcement time differed between the schedules. The slopes of

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lines relating pause duration to interreinforcement times were typically (but not always) steeper for FR schedules than for FI schedules, a result which suggests that pausing may not be controlled similarly by interreinforcement time under these two types of schedules.

Shull (1979) offered an account of pausing that emphasizes the remaining response requirement or the time to reinforcement following the pause. Responding under periodic schedules can be compartmentalized into two classes of activities: terminal behavior directed toward the scheduled reinforcer and nonterminal behavior directed toward other reinforcers (cf. Staddon & Simmelhag, 1971). Nonterminal behavior presumably consumes most of the postreinforcement pause, while terminal behavior occupies most of the remainder of the interreinforcement interval. Shull (1979) suggested that pause duration is not controlled by the entire interreinforcement interval, but by only that portion of the interval occupied by terminal behavior: the "work time" interval.

A clear distinction between time devoted to terminal behavior and time devoted to nonterminal behavior in standard reinforcement schedules is difficult at best, because the terminal behavior typically consists of discrete responses, usually key pecks or lever presses. The execution of such discrete responses consumes a relatively small amount of time; the assumption that the time between responses is uniformly devoted to terminal activity is arbitrary. Nonetheless, work time typically has been estimated by subtracting postreinforcement pause duration from the entire interreinforcement interval (Shull, 1979). This method of estimating work time ties the work-time and interreinforcement-time variables together, so that a separation of their potential effects on pausing is virtually impossible. Pause duration, for example, will necessarily be better correlated with interreinforcement time than with this estimate of work time because interreinforcement time is the sum of the pause time and estimated work time. A less ambiguous assessment of the relation between pause duration and work time could be made with an estimate of work time that is not derived from interreinforcement time.

The present study examined postreinforcement pausing with a continuous response, lever holding, in lieu of the usual lever-pressing respnse. Instead of discrete lever presses being reinforced, food deliveries were contingent upon rats' holding down a lever for fixed, cumulative periods of time. Standard FR schedules require the emission of a fixed number of discrete responses for reinforcement; with the continuous-response procedure of the present study, reinforcement depended upon the allocation of a fixed amount of time to an activity. Thus, this procedure permitted an estimate of work time that was not derived from interreinforcement time. The portion of an interreinforcement interval occupied by terminal behavior, the work time, can be estimated as that portion of the interval during which the lever was down.

METHOD

Subjects

Six experimentally naive male Long Evans hooded rats were maintained at 85% of their free-feeding weights. The rats were four months old at the start of the experiment.

Apparatus

A Gerbrands Model C experimental chamber was enclosed in a Lehigh Valley Electronics sound-attenuating cubicle. The chamber was 19.3 cm high, 23.5 cm long, and 20.4 cm wide. A Gerbrands G6312 Rat Lever, 5.1 cm wide and 1.3 cm thick, protruded 1.4 cm from the front wall of the chamber, 8.2 cm above the grid floor. Reinforcers in the form of 45-mg Noyes Precision Food Pellets were dispensed into a receptacle extending 5.0 cm behind the front wall of the chamber. The food receptacle was accessible through an aperture, 4.5 cm high and 4.5 cm wide, which extended from 4.6 cm left of the center of the lever to 1.2 cm from the left side of the chamber.

A houselight, 4.6 cm directly above the top of the food receptacle, provided general illumination during experimental sessions. A fan attached to the sound-attenuating chest ventilated the experimental space. A large floor fan in the room containing the experimental chamber generated a constant hum that helped mask extraneous sounds. Solid-state equipment supplemented by some electromechanical equipment was used to control reinforcement contingencies and collect data from an adjacent room.

Procedure

The rats initally were given two 60-min sessions in which each lever-press response was reinforced and in which reinforcement was delivered every 60 s independently of responding (conjoint fixed-ratio 1 fixed-time 60 s), followed by one session in which FR 1 was in effect. Subsequently, all reinforcers were contingent upon the lever being held down for a specified period of time. The hold requirements for the fourth through seventh sessions were 1, 2, 4, and 8 s, respectively. After this pretraining, the hold requirement was 15 s for each rat. It was not necessary that the lever be held down continuously for a specified duration, but only that the time the lever was held down totaled a specified duration. With a hold requirement of 15 s, for example, reinforcement would be produced by holding down the lever continuously for 15 s or by five separate bouts of lever holding, each of 3-s duration.

Lever holding was measured in 0.5-s intervals. Pulses generated every 0.5 s were routed through a relay that was operated by the lever. When the lever was held down, pulses operated a predetermining counter that determined the hold requirement for reinforcement. Lever-holding responses shorter than 0.5 s in duration did not necessarily contribute to the cumulative hold duration; such short-duration responses contributed only if one of the pulses generated every 0.5 s happened to occur while the lever was down, thereby operating the predetermining counter. When the predetermining counter reached zero, it reset, reinforcement was provided, and 0.5-s pulses operated a cumulative pause-time counter until the lever was again pressed. Pauses were terminated by any lever press, regardless of its duration. However, the logic circuitry prevented lever presses within 0.5 s after reinforcement from terminating a pause.

Several different hold requirements were imposed over experimental conditions. Generally, an experimental condition was changed when pausing was considered stable: The mean pause duration in any of five consecutive sessions did not deviate by more than 15% of the mean of those five daily means and no consistent trend in pause duration was evident. Conditions occasionally were changed even though these stability criteria were not met. This occurred with relatively long and relatively short hold requirements, at which responding was not maintained uniformly throughout experimental sessions.

Experimental sessions were terminated with the first reinforcement after 60 min or after 75 min even if reinforcers had not been obtained. This latter session-ending criterion was met rarely, except during experimental conditions in which lever holding was not maintained uniformly throughout sessions and stable pausing was not obtained. With few exceptions, sessions were conducted seven days per week at about the same time each day.

A series of hold requirements was conducted in each of two separate phases of the experiment. The hold requirements of Phase I were presented in ascending order, beginning with 15 s. When stable pausing was obtained, the hold requirement was raised to 30 s, and then raised in 30-s steps over successive experimental conditions until lever holding was no longer maintained reliably. Subsequently, Phase II comprised a second series of hold requirements, these presented in irregular order over experimental conditions. The hold requirements of Phase I and the number of sessions each requirement was in effect are presented in Table 1. The hold requirements of Phase II, their order of presentation, and the number of sessions

Table 1

Sequence of scheduled hold requirements, number of sessions in each experimental condition of Phase I, and summary data for lever-holding time, postreinforcement pause duration, session time, reinforcers, and responses, averaged over the last five sessions of each condition. Ranges for those five sessions are given in parentheses. Conditions in which stable responding was not obtained are indicated by asterisks. These conditions usually contained sessions that were terminated during a pause. Consequently, the mean pause durations given for "unstable" conditions include those partial pauses.

Hold Requirement (seconds)	*Order of Presentation*	*Number of Sessions*	*Time Spent Lever Holding (seconds)*	*Postreinforcement Pause Duration (seconds)*	*Session Time (seconds)*	*Reinforcers*	*Responses*
Rat 108							
15	1	24	2,649(150)	4.9(.6)	3,606(7)	176.6(10)	262(62)
30	2	43	2,892(120)	6.7(.6)	3,622(38)	96.4(4)	292(103)
60	3	123	2,172(300)	38.7(6.9)	3,698(112)	36.2(5)	154(100)
90*	4	46	918(630)	281.8(467.1)	4,322(888)	10.2(7)	57(54)
Rat 109							
15	1	38	2,289(135)	5.7(.8)	3,612(20)	152.6(9)	808(166)
30	2	25	2,472(180)	7.3(.7)	3,619(42)	82.4(6)	1,320(568)
60	3	72	1,944(300)	19.0(2.9)	3,701(365)	32.4(5)	374(149)
90	4	25	1,674(540)	34.7(7.5)	3,675(144)	18.6(6)	237(107)
120*	5	51	576(240)	204.3(409.3)	4,500(0)	4.8(2)	29(19)
Rat 110							
15	1	23	1,926(180)	7.8(1.1)	3,619(28)	128.4(12)	2,601(1,061)
30	2	40	1,944(210)	18.6(3.3)	3,627(140)	64.8(7)	733(454)
60	3	117	648(420)	86.5(20.6)	4,224(776)	10.8(7)	88(68)
90*	4	34	666(270)	162.4(187.2)	4,107(652)	7.4(3)	88(42)
Rat 111							
15	1	29	2,214(45)	4.0(.7)	3,617(15)	147.6(3)	709(87)
30	2	42	2,244(270)	6.4(.8)	3,626(71)	74.8(9)	751(135)
60*	3	142	396(420)	176.0(198.6)	4,500(0)	6.6(7)	146(148)
Rat 112							
15	1	27	2,535(150)	6.0(1.1)	3,619(19)	169.0(10)	341(87)
30	2	44	2,640(360)	6.6(.7)	3,645(31)	88.0(12)	444(289)
60	3	62	3,036(180)	6.1(1.1)	3,640(61)	50.6(3)	257(54)
90*	4	77	1,278(2,340)	35.5(120.8)	4,230(776)	14.2(26)	132(166)
Rat 113							
15	1	28	2,478(225)	6.7(.9)	3,644(127)	165.2(15)	246(35)
30	2	37	2,502(120)	10.7(1.5)	3,634(52)	83.4(4)	405(286)
60	3	73	1,332(480)	53.3(12.7)	3,905(620)	22.2(8)	132(46)
90	4	52	1,242(180)	105.6(27.1)	3,822(431)	13.8(2)	110(52)
120*	5	17	888(480)	158.5(84.5)	3,753(292)	7.4(4)	93(48)

*unstable

each requirement was in effect are presented in Table 2.

Only postreinforcement pausing was measured in Phase I; time between the beginning of a session and the first response in a session was not recorded. Time between the beginning of a session and the first response was recorded and included in calculating mean pause durations in Phase II.

Cumulative records of lever holding were collected during Phase II of the experiment; whenever the lever was down, pulses generated every 0.5 s operated the stepping pen of a cumulative recorder, as discrete responses normally do. Lever-holding responses with durations shorter than 0.5 s did

Table 2

Sequence of scheduled hold requirements and number of sessions in each experimental condition of Phase II. Summary data are as described in Table 1, except that mean pause duration in Phase II includes the time between the beginning of a session and the first response.

Hold Requirement (seconds)	*Order of Presentation*	*Number of Sessions*	*Time Spent Lever Holding (seconds)*	*Pause Duration (seconds)*	*Session Time (seconds)*	*Reinforcers*	*Responses*
Rat 108							
7.5*	5	11	1,577(263)	11.4(6.9)	4,258(921)	210.2(35)	492(112)
15	3	16	1,908(240)	8.8(2.4)	3,641(60)	127.2(16)	297(38)
30	2	28	1,608(180)	33.1(8.9)	3,625(189)	53.6(6)	293(50)
45	4	48	2,160(90)	28.3(4.4)	3,648(46)	48.0(2)	197(99)
60	6	31	2,568(240)	19.3(3.5)	3,666(134)	42.8(4)	214(100)
75*	1	21	1,020(825)	184.2(362.6)	4,393(537)	13.6(11)	98(122)
75	7	13	1,875(750)	41.6(6.0)	3,631(122)	25.0(10)	390(256)
Rat 109							
15	4	22	765(90)	47.7(7.4)	3,659(60)	51.0(6)	163(76)
30	6	19	972(180)	62.0(10.9)	3,639(60)	32.4(6)	174(23)
45	5	15	1,206(180)	67.5(8.7)	3,715(145)	26.8(4)	160(45)
60	7	45	1,044(240)	88.7(21.2)	3,624(81)	17.4(4)	162(87)
75	3	30	1,230(150)	79.2(22.9)	3,836(472)	16.4(2)	61(11)
90	2	11	1,098(270)	103.0(23.1)	3,751(290)	12.2(3)	38(11)
105*	1	24	1,071(735)	119.6(140.6)	4,500(0)	10.2(7)	35(16)
Rat 110							
7.5	4	29	630(45)	30.0(2.6)	3,632(33)	84.0(6)	315(44)
15	3	34	417(135)	62.2(13.0)	3,630(46)	27.8(9)	295(49)
30	5	17	732(150)	72.1(19.2)	3,665(110)	24.4(5)	404(83)
45	6	12	846(135)	70.9(4.2)	3,744(96)	18.8(3)	454(161)
60*	2	25	312(660)	127.7(127.4)	4,262(624)	5.2(11)	62(117)
60	7	36	900(120)	82.9(18.4)	3,736(305)	15.0(2)	336(87)
75*	1	24	540(525)	188.3(346.4)	4,249(894)	7.2(7)	87(85)
Rat 111							
7.5	3	29	570(143)	33.7(9.6)	3,654(122)	76.0(19)	315(199)
15	4	21	714(60)	48.7(7.2)	3,624(47)	47.6(4)	410(114)
30	2	57	828(90)	69.8(11.2)	3,638(94)	27.6(3)	352(84)
45*	1	47	306(225)	106.5(230.3)	4,500(0)	6.8(5)	111(58)
Rat 112							
7.5*	8	10	1,286(278)	11.8(4.2)	3,653(38)	171.4(37)	466(130)
15	4	12	2,430(195)	5.3(1.0)	3,618(45)	162.0(13)	300(40)
15	6	17	2,607(120)	4.3(.7)	3,647(15)	173.8(8)	457(113)
30	5	36	2,838(60)	4.9(.4)	3,614(20)	94.6(2)	241(47)
45	3	27	2,943(180)	5.5(.7)	3,633(39)	65.4(4)	246(71)
60	2	19	2,940(180)	6.5(1.2)	3,640(42)	49.0(3)	246(48)
75	1	16	2,730(300)	8.1(3.1)	3,655(35)	36.4(4)	239(50)
90	7	34	3,006(90)	10.2(3.0)	3,646(84)	33.4(1)	229(74)
105	9	16	3,024(315)	10.8(2.9)	3,642(91)	28.8(3)	268(80)
Rat 113							
15	3	23	2,319(240)	7.0(1.6)	3,643(34)	154.6(16)	354(34)
45	4	29	2,124(90)	24.1(1.6)	3,680(124)	47.2(2)	226(38)
75	5	23	2,115(375)	40.3(9.9)	3,881(188)	28.2(5)	207(87)
90	2	63	1,242(180)	112.1(9.6)	3,800(498)	13.8(2)	121(55)
105	1	47	1,050(420)	145.8(33.5)	4,180(1,479)[a]	10.0(4)	76(48)

*unstable

[a]includes one session that lasted 5,165 seconds

not necessarily operate the stepping pen; such short-duration responses operated the stepping pen only if one of the pulses generated every 0.5 s happened to occur while the lever was down.

RESULTS

Stable responding was maintained at hold requirements as long as 60 s to 105 s for five of the six rats; stable responding was maintained at hold requirements no longer than 30 s for Rat 111. At longer hold requirements, lever holding for all rats was generally erratic and pausing was unstable, with most of the lever holding that occurred being early in sessions and ceasing altogether later in sessions.

Mean pause duration is plotted with respect to the scheduled hold requirement for each rat in Figure 1. The lines through the data points in each panel of Figure 1 were derived by the method of least squares. The corresponding least-squares linear regression equation is given for each rat; the coefficient of determination, r^2, indicates the proportion of variance in pause duration that is accounted for in terms of variation in hold requirement.

The scheduled hold requirement represents the actual time rats held down the lever per reinforcer and, hence, the actual measured time devoted to terminal behavior. Pause duration was uniformly short across all three hold requirements of Phase I for Rat 112. With this exception, pause duration typically increased with the scheduled hold requirement whether the individual hold requirements were presented in ascending (Phase I) or irregular (Phase II) order. However, Phase I and Phase II produced somewhat different relationships between pause duration and hold requirement for Rats 108, 109, 110, and 111, as assessed by the substantially different slopes and intercepts of the least-squares lines in the two phases. The differences in slopes were unsystematic but the intercept for each of those four rats was higher in Phase II than in Phase I. For those rats, pause duration was considerably longer in Phase II than in Phase I at relatively short hold requirements.

Mean pause duration is plotted with respect to the mean interreinforcement time for each rat in Figure 2. Least-squares linear regression lines are drawn through the data points; the corresponding equations and coefficients of determination are provided. Pause duration generally increased with the mean interreinforcement time during both Phase I and Phase II. Rat 112 again provides an exception, in that pause duration was uniformly short throughout Phase I for this rat.

For most rats, interreinforcement time accounted for somewhat more variance in pause duration than did the scheduled hold requirement. Based on r^2 values, the scheduled hold requirement provided a better estimate of pause duration only for Rat 112 during Phase II. In addition, the intercepts of the lines relating pause duration to interreinforcement time were consistently closer to zero than the intercepts of the lines relating pause duration to hold requirement.

Figure 3 presents pause duration plotted with respect to interreinforcement time minus pause duration, which has been used previously to estimate work time (see Shull, 1979). Least-squares linear regression lines are drawn through the data points; the corresponding equations and coefficients of determination are provided. Data in Figure 3 are from Phase II only. The estimate of work time described by Shull (1979) was not measured in Phase I and cannot be deduced by subtracting pause times from session times because only postreinforcement pausing was recorded; time between the beginning of a session and initiation of lever holding was not measured in Phase I.

Pause duration generally increased with increases in this estimate of work time for all rats. Comparisons of this estimate of work time to the actual lever-holding time represented in Figure 2 as predictors of pause duration reveal no systematic differences. Based on r^2 values, pause duration was better correlated with Shull's (1979) estimate of

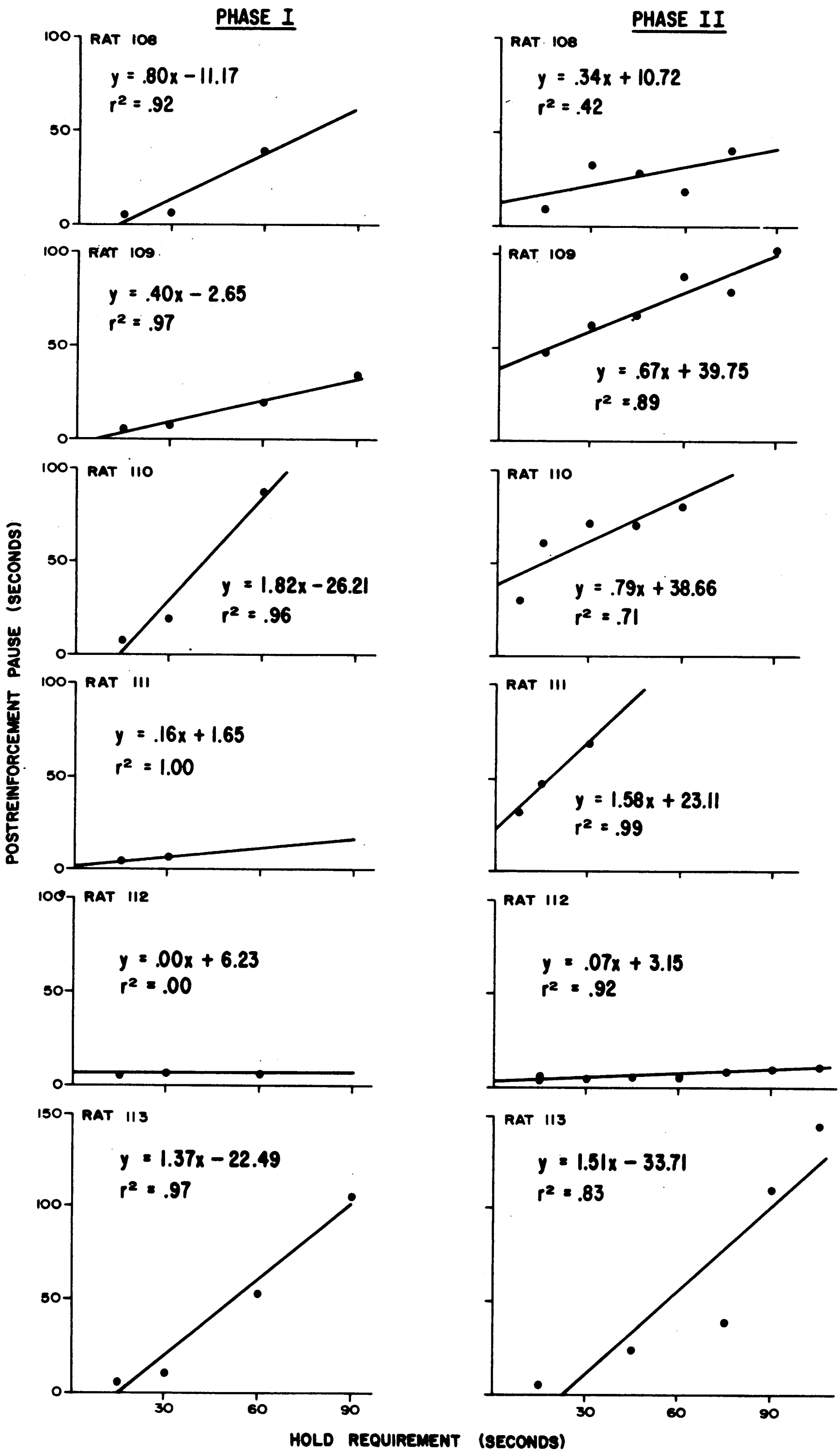

Fig. 1. Mean pause duration plotted with respect to the scheduled hold requirement. Data are from the last five sessions of each condition that produced stable pausing.

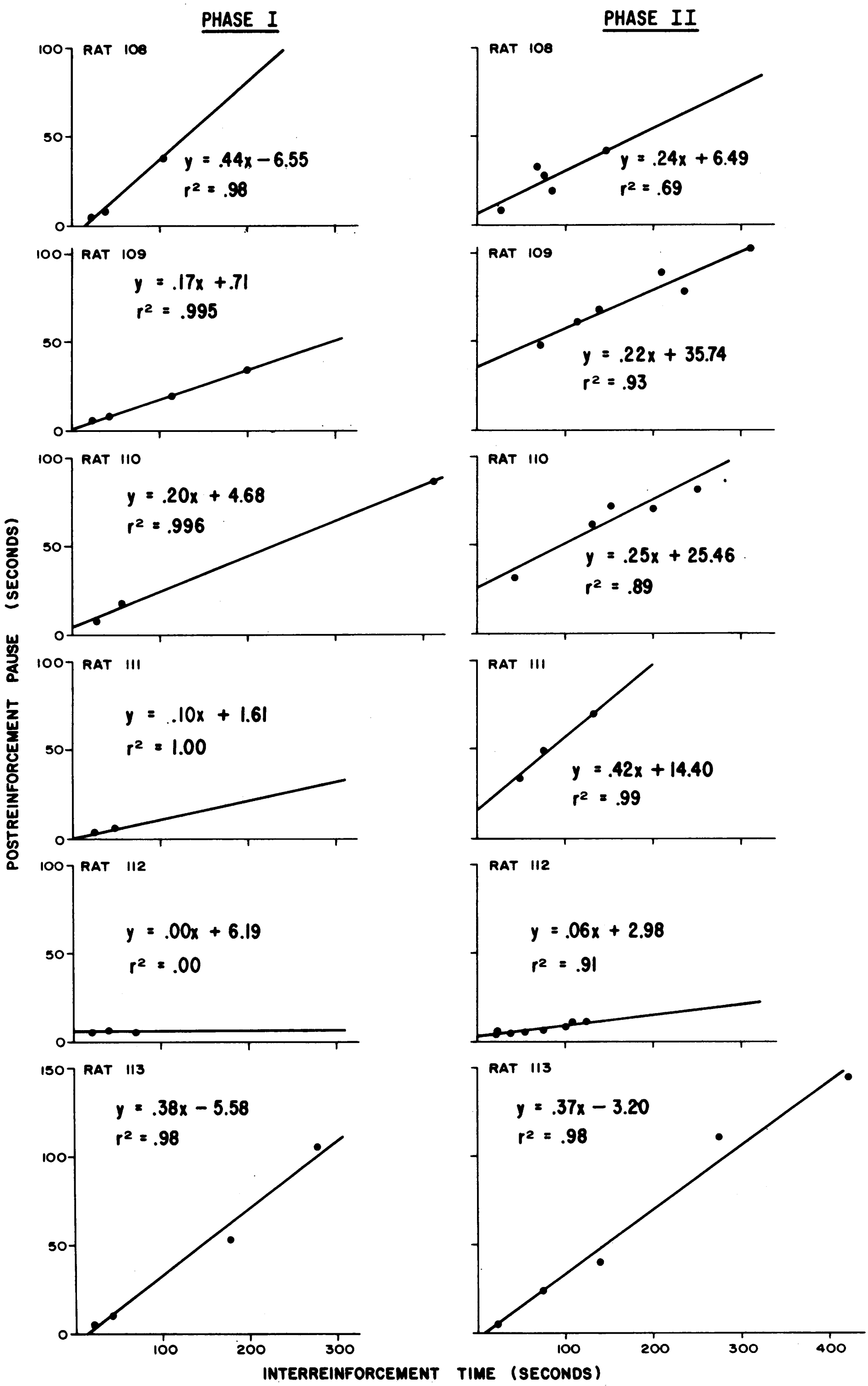

Fig. 2. Mean pause duration plotted with respect to the mean interreinforcement time. Data are from the last five sessions of each condition that produced stable pausing.

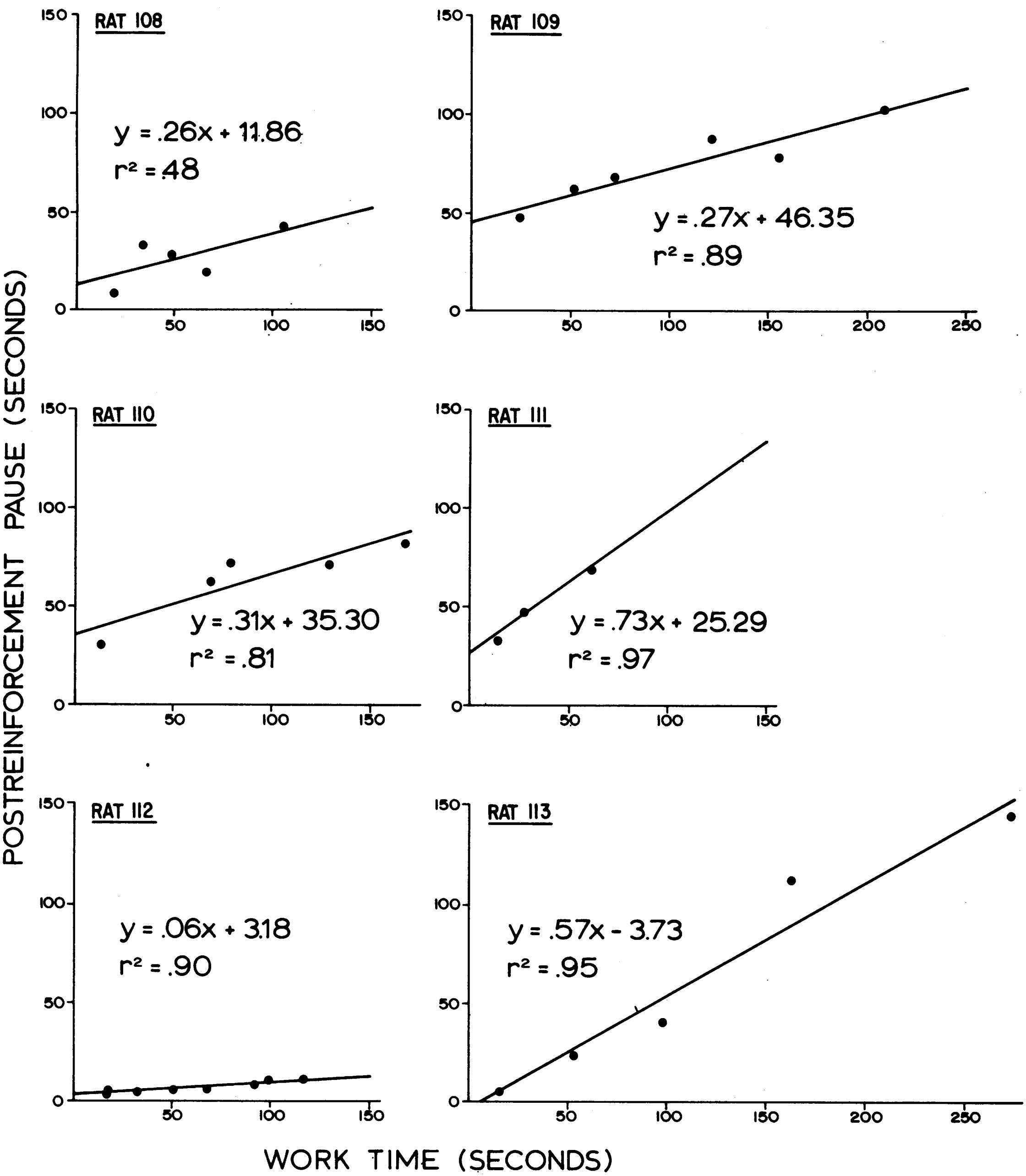

Fig. 3. Mean pause duration plotted with respect to the mean work time, which represents the time between initiation of lever holding and subsequent delivery of the reinforcer. Data are from the last five sessions of each condition that produced stable pausing during Phase II.

work time than with actual lever-holding time for some rats but not for others. Similarly, no consistent differences between the two estimates of work time were obtained in the intercepts of the regression lines.

Cumulative records of lever holding in Phase II are presented in Figures 4, 5, and 6 for Rats 109, 111, and 113, respectively. These records are representative of lever-holding performance over the range of hold requirements employed in the present study. The proportion of session time spent lever

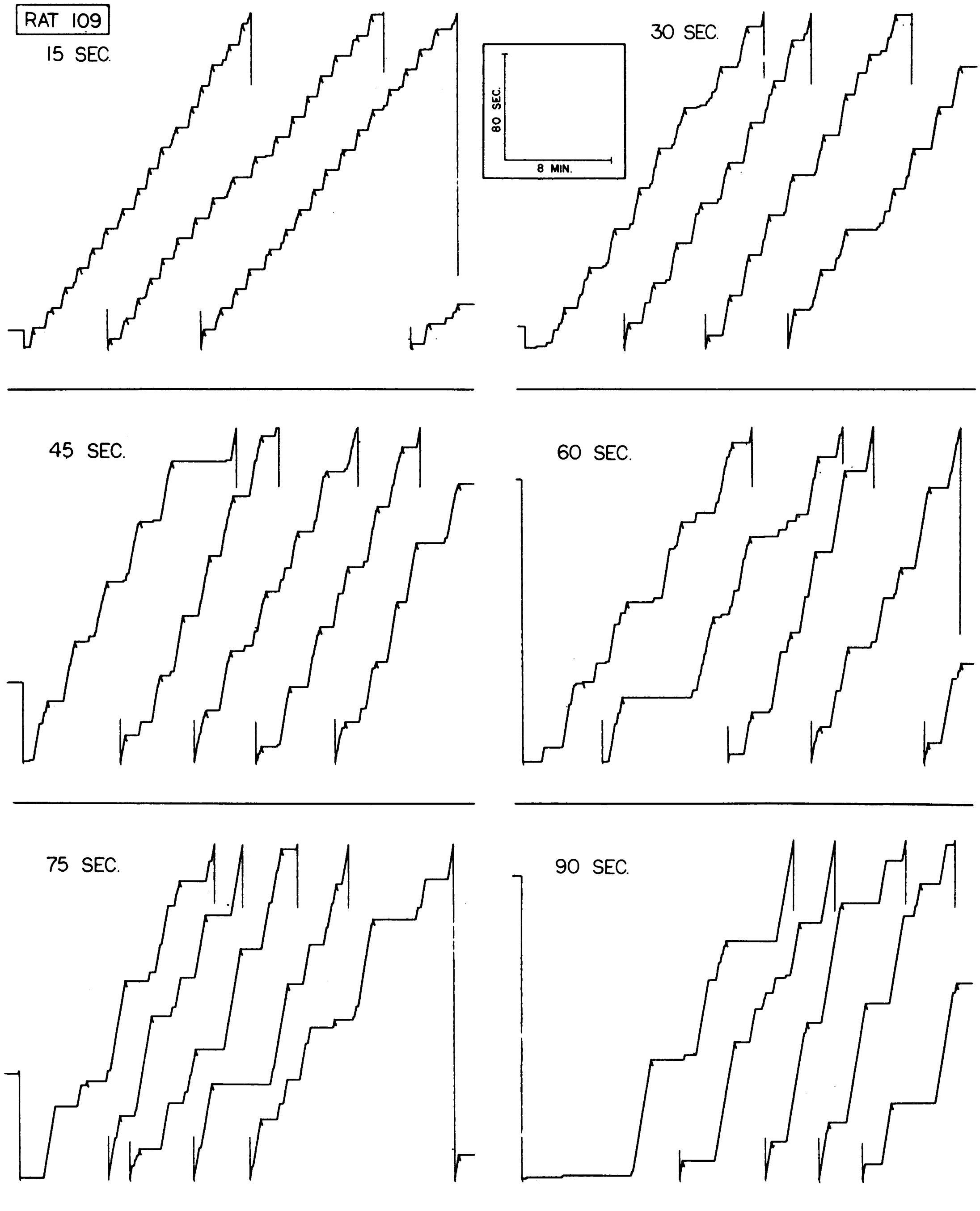

Fig. 4. Cumulative records of complete sessions of lever holding for Rat 109. Each record is representative of stable responding during the last five sessions of a condition. The response pen advanced once per half second when the lever was held down; diagonal slashes of the pen indicate deliveries of the reinforcer.

holding (indicated by the slope of a record) and the longest hold requirement to maintain stable responding varied widely across rats. Nonetheless, the pattern of lever holding was similar for all rats, resembling that of responding under FR schedules. Periods of no lever holding immediately after reinforcement alternated with virtually contin-

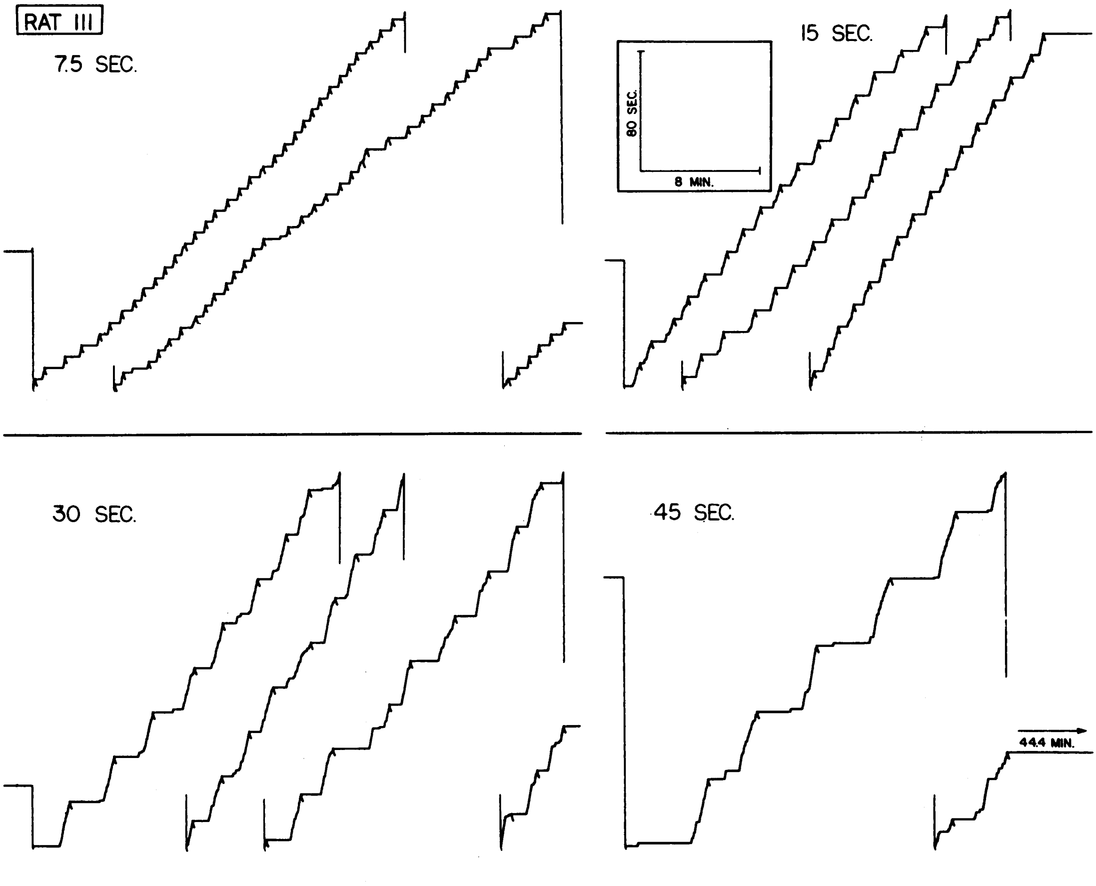

Fig. 5. Cumulative records of complete sessions of lever holding for Rat 111. Each record is representative of stable responding during the last five sessions of a condition except the record of responding under the hold requirement of 45 s, in which stability criteria were not met. The response pen advanced once per half second when the lever was held down; diagonal slashes of the pen indicate deliveries of the reinforcer.

uous lever holding until the next reinforcement delivery at short hold requirements. However, even the shortest hold requirements rarely were completed with a single lever-holding response. Rather, the lever usually was held down and released several times within the interreinforcement interval, although the lever was released for very brief periods. As the scheduled hold requirement became longer, interruptions in postpause lever holding generally became longer in duration, as indicated by the rougher grain of cumulative records at intermediate hold requirements. At the longest hold requirements, postpause lever holding often occurred in bursts that were interrupted with additional pauses. Figure 5 includes a record of lever holding for Rat 111 at a hold requirement of 45 s which did not maintain stable responding. Lever holding was somewhat erratic early in this session but then ceased altogether about 30 min into the session. This general pattern was typical of unstable responding for all rats at relatively long hold requirements.

Tables 1 and 2 include numerical data from Phases I and II, respectively. Entries for lever-holding time, session time, reinforcers, and responses (number of times the lever was pressed and then released) are means per session over the last five sessions of each condition. Entries for pause duration are means per reinforcer. The mean pause duration per reinforcer was calculated for in-

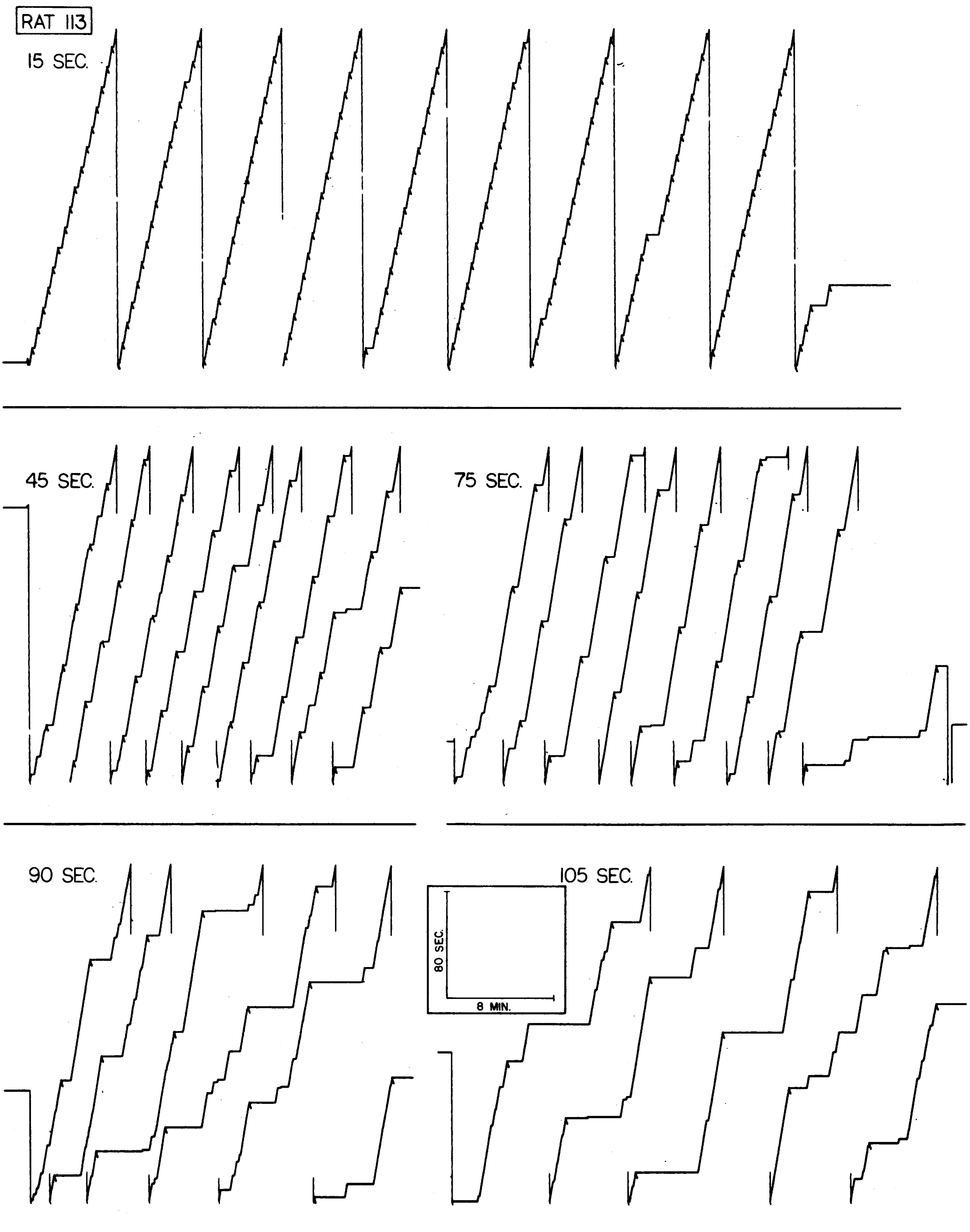

Fig. 6. Cumulative records of complete sessions of lever holding for Rat 113. Each record is respresentative of stable responding during the last five sessions of a condition. The response pen advanced once per half second when the lever was held down; diagonal slashes of the pen indicate deliveries of the reinforcer.

dividual sessions; the tabled values are means of those daily means over the last five sessions of each condition.

DISCUSSION

Lever holding was maintained in all six rats when reinforcement depended on cumulative holding time. Breaks in lever holding reliably followed each reinforcer and the mean duration of these postreinforcement pauses typically increased with the scheduled hold requirement. The break-run pattern of responding generated by the lever-holding requirement resembles that generated by FR schedules of reinforcement contingent upon discrete responses. Also, the relationship between pause duration and scheduled hold requirement is comparable to that characteristic of other schedules that provide reinforcement periodically. Thus, these findings extend the generality of the break-run pattern of responding and the relationship between pause duration and schedule requirement to schedules providing periodic reinforcement for a continuous response.

Judging from r^2 values, the mean time between reinforcers provided a good estimate of pause duration, with few exceptions. The good linear fit between pause duration and interreinforcement time is consistent with previous findings (Nevin, 1973; Rider, 1980). It should be noted, however, that the correlation between pause duration and interreinforcement time is inflated somewhat because interreinforcement time contains the pause time.

Capehart et al. (1980) found that pause duration differed under FR and FI schedules even when similar interreinforcement times were obtained from those schedules. They concluded that FR and FI schedules do not control pausing comparably. Those findings do not necessarily imply that interreinforcement time does not control pausing under either schedule, but only that the relationship of pausing to interreinforcement time is mitigated by the scheduling arrangement. Results of Capehart et al. (1980) are consistent with this possibility, as are those of the present study.

Shull's (1979) estimate of work time, measured as the time between initiation of lever holding and delivery of reinforcement, and the actual time spent lever holding also provided good estimates of pause duration, with few exceptions. Lever-holding time has an advantage as an estimate of work time because it is a direct measure of the time devoted to terminal behavior. Because this estimate of work time is not derived from the interreinforcement time, a more meaningful comparison of work time and interreinforcement time as predictors of pause duration can be made. Results from the present study are equivocal: Interreinforcement time accounted for more variance in pause duration than did lever-holding time in most cases, but the differences were not consistently large. Moreover, lever-holding time still is only an estimate of the actual work time. As Shull (1979) noted, the portion of an interreinforcement interval that is measured as work time may not reflect that portion of the interval truly devoted to terminal activity.

Two sources of error in measuring terminal activity can be identified: unmeasured terminal behavior and nonterminal behavior incorrectly measured as terminal behavior. Unmeasured terminal behavior would include positioning oneself before the response key or lever and pecking or pressing with insufficient force to register as a response. The problem of unmeasured terminal behavior persists with lever holding as it does with discrete responses. But it is not clear how this potential source of error affects the relationship between pause duration and work time. Assuming that the majority of unmeasured terminal behavior consists of moving in front of the response key or lever and other responses preparatory to key pecking or lever pressing, these activities probably consume a fairly constant amount of time in each interreinforcement interval. The addition of a relatively constant value to the measured work times over experimental conditions would have little effect on the proportion of variance accounted for in terms of those work times.

The use of lever-holding time to estimate work time eliminates the potential error of nonterminal behavior incorrectly measured as terminal behavior. With discrete responses, work time has been measured from the first postreinforcement response to the next reinforcement. The assumption that only terminal behavior occurs during this interval under FR schedules may be justified by the uniformly high postpause response rates generated by those schedules. But the extreme variability in response rates under FI schedules, both within and across interreinforcement intervals (see Skinner, 1938, pp. 123-126; Zeiler, 1977, 1979), makes this assumption less tenable. Further, animals frequently alternate between FI and other concurrently available reinforcement schedules (see Catania, 1962; Ferster & Skinner, 1957, pp. 705-717; Nevin, 1971; Rider, 1981), and between FI responding and other measured activity that is not explicitly reinforced (Skinner & Morse, 1957), even after the first postreinforcement FI response. Similarly, lever holding in the present study did not always continue uninterrupted from the time lever holding began until the delivery of reinforcement, especially at long hold requirements.

The schedules of reinforcement for lever holding used in the present study represent a blend of ratio-like and interval-like contingencies that is distinct from other complex schedules. Delivery of reinforcement under conjunctive (e.g., Herrnstein & Morse, 1958; Zeiler & Buchman, 1979), interlocking (Berryman & Nevin, 1962; Powers, 1968; Rider, 1977), alternative (Rider, 1980), and some second-order schedules (cf. Kelleher, 1966; Rider, 1982) depends on a combination of responses and passage of time. Under schedules of reinforcement contingent upon lever holding, reinforcement depends on a response that is defined in terms of the passage of time. Like standard ratio schedules, reinforcement depends on the completion of a response requirement; but like standard interval schedules, the minimum interreinforcement time is predetermined. By defining a response in terms of a continuous activity such as lever holding, the concepts of work and work time are united.

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