RATIO RESPONDING AS A FUNCTION OF CONCURRENT AVOIDANCE SCHEDULES, YOKED SHOCKS AND RATIO VALUE

By

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A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL
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In dedication to Richard D. Willis whose efforts as a professor and a friend made this paper a reality.

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Fixed-ratio responding in rats was maintained alone, concurrent with shock avoidance, or concurrent with response-independent shocks matched to those that occurred in the avoidance condition for one subject. Under each condition, fixed-ratio size was increased over successive daily sessions. Fixed-ratio response rate generally passed through a maximum as a function of fixed-ratio size. The maximum occurred when 1) the time to complete a fixed-ratio approximated the response-shock interval of the avoidance schedule, 2) the shock rate increased, and 3) the ratio requirements were so high that ratio strain occurred. Avoidance rates decreased to an asymptotic value as fixed-ratio size increased.

Introduction

Previous studies determining the effects of one operant on others have primarily used the same reinforcer, usually food, in the different individual schedules. Further investigations are needed to determine the effects of one operant maintained by a specific reinforcer on another operant maintained by a different reinforcer.

In general, responding when the reinforcement rate is relatively constant decreases as a function of reinforcement from other sources such as a concurrent schedule (see Catania, 1973 for discussion). Such a relation may hold only when all the reinforcers are the same. In concurrent schedule studies using food and water as reinforcers, decreasing the reinforcement rate for one response increased that response but had little effect on responding maintained by the other reinforcer (Wood and Willis, 1974; Wood et al., 1975). Resolution of this issue with food and water is difficult because of the problems involved in determining the nature of the interactions of these complex and sensitive reinforcers (see Willis et al., 1974). Concurrent schedule studies using different reinforcers with less well known interactions, such as food and shock avoidance, would be preferable in initial studies.

Two experiments have looked at concurrent schedule responding maintained by food reinforced and shock-avoidance schedules. The first one was an attempt to maintain schedule appropriate behavior to each schedule. Sidman (1958) studied responding to a concurrent

variable-interval (VI) Sidman avoidance (AV) schedule. Pulling a chain produced food according to a VI 4 minute schedule. Pressing a lever was maintained by an AV schedule with the response-shock (RS) and shock-shock (SS) intervals both equal to 20 seconds. Under these avoidance contingencies each response delayed the shock for 20 seconds (RS 20 sec). If no response was made shocks would occur every 20 seconds (SS 20 sec). Because of the high rate of switching between operants, preventing independence in responding to each schedule, Sidman changed the VI to a fixed-ratio (FR) schedule. Under concurrent (conc) FR AV contingencies switching decreased and responding was maintained appropriate to each schedule's requirements.

Catania, Deegan and Cook (1966) compared the effects of responding to a concurrent FR AV schedule with responding for each schedule's contingencies alone. Pressing one lever produced food according to an FR 100 schedule. Pressing a second lever was maintained by a modified Sidman avoidance schedule, with the RS and SS intervals both equal at 30 seconds. The removal of either lever did not affect the rate or pattern of the other response. These results were similar to those of Kelleher and Cook (1950) in which the FR and AV contingencies were concurrently programmed to responses on one lever.

Sidman (1958), Catania et al. (1966) as well as Kelleher and Cook (1959) used only one fixed-ratio and one Sidman avoidance value. In the present experiment a procedure was used that allowed for a wide range of reinforcement rates on one schedule while keeping the value constant on the other schedule. The procedure was introduced by Wood and Willis (1974). Using concurrent fixed-ratio fixed-interval (conc FR FI) schedules, Wood and Willis increased the FR value

daily by a constant multiple of the preceding day while keeping the FI value constant. Cumulative records and response rates to these daily FR increases did not differ from those under procedures where repeated presentations of the same FR values were employed (LaBounty and Reynolds, 1973; Wood, Martinez and Willis, 1975). Such a procedure allows a comparison of rates and patterns of responding to schedules maintained by the same and by different reinforcers (food and water) as a function of a wide range of FR values.

The present experiments extend the generality of the previous findings in which different reinforcers were scheduled concurrently. The Wood and Willis (1974) procedure (increasing the FR value daily while keeping the other schedule constant) was used with conc FR AV schedules and compared to FR alone and FR matched shock conditions.

Method

Subjects. The subjects were three male hooded rats of Long Evans descent. Each subject was deprived to approximately 70% of its *ad libitum* weight. Two rats (21a and 35) were experimentally naive and the other (33) had been previously run on the same Wood and Willis (1974) procedure with *conc* FR VI schedules of food and water reinforcement.

Apparatus. Experimental sessions were conducted in two operant chambers each containing two retractable levers, 3.0 cm above the grid floor and 14.0 cm apart. The force required to operate each lever was approximately 0.20 N. A food magazine was 4.0 cm to the left of the right lever. A 2.5 sec tone accompanied delivery of 0.045 gram Noyes standard pellets. A constant-current shock generator delivered 0.5 sec, 0.8 ma a.c. scrambled shocks through the grid floor. Masking noise was continuously present except for 30 msec following a response: the resulting "pop" served as response feedback. Dim illumination was provided by a 7.5 watt lamp. The chamber was located in a sound- and light-attenuating box. Standard electromechanical scheduling and recording equipment was located in an adjacent room.

Procedure. For Rats 21a and 33 responses to the right lever were established under the FR schedule with the left lever retracted. The subjects were trained under the AV schedule with the right lever retracted. These session were followed by sessions in which the

levers were available alternately until the right lever controlled responding appropriate to the FR schedule and the left lever controlled responding appropriate to the AV schedule. Responding was then allowed to develop on a conc FR 10 AV (RS 30 sec SS 10 sec) schedule with both levers present. Baseline conditions of stable weight and responding were defined as less than a 3 gram difference in body weight and 2.0 response per min difference in responding over a period of 5 or more days, and maintained prior to any change of schedule values. Daily sessions ended when the subject received its daily food allotment within a session (330 pellets for 21a and 370 pellets for 33) or when 90 min had elapsed, whichever came first. To maintain stable body weights supplemental food was given after the session when the daily allotment of food was not received during the session.

Next, the ratio requirement was increased from FR 10 by a factor of 1.2 (rounded to the nearest tenth) each session (10, 12, 14, 17, ...) until the subject's FR response rate clearly approached zero (in all but one ascending series the resulting FR response rate on the last session was below 4 per min). Baseline responding was then developed on another conc FR 10 AV (RS X-sec SS 10-sec) schedule (X being 7.5 sec, 15 sec or 60 sec). For Rat 33 the RS interval was 30 sec in the first FR ascending series, 15 sec in the second FR ascending series and 7.5 sec in the third FR ascending series. For Rat 21a the RS interval was 30 sec in the first FR ascending series, 15 sec in the second FR ascending series, and 60 sec in the third FR ascending series (conc FR RS 7.5 sec AV conditions did not result in stable responding, so a conc FR RS 60 sec AV schedule was used). For both

rats a fourth FR ascending series was used with the FR schedule alone (the AV lever was absent).

Next a VIAV schedule (DeVilliers, 1974) was developed for responses to the left lever with the right lever retracted. In this schedule the first response after a tape meter detects a hole in a tape of variable intervals (Fleshler and Hoffman, 1962) avoids the next scheduled shock delivery. The proportion of short intervals in this schedule produces steady maintained responding. Failure to respond results in shock delivery upon each hole detection. These sessions were followed by sessions establishing multiple schedule behavior during which the levers alternated until the right lever controlled responding appropriate to the FR schedule and the left lever controlled responding appropriate to the AV schedule. Responding was then developed on a conc FR 10 VI 15 sec AV schedule with both levers present. At this point in the investigation Rat 33 became ill and eventually died before systematic data could be collected. The procedure was continued with Rat 21a. Baseline conditions of stable weight and responding were maintained prior to any change of schedule values. Food allotment and session duration procedures were identical to those under conc FR AV conditions.

The ratio requirement was increased from FR 10 by a factor of 1.2 for each session to the ratio at which the subject's FR response rate was less than 10 per min. Baseline responding was then established on another conc FR 10 VI X AV schedule. The VI value was 15 sec in the first FR ascending series, 7.5 sec in the second FR ascending series and 30 sec in the third FR ascending series.

Another set of FR ascending series was used with Rats 21a and

35. For Rat 35 the FR schedule was developed to responses on the right lever. Responding for both rats was then developed on a FR 10 schedule and matched to Rat 33's previously received baseline shocks. The subjects received each shock at the same temporal point in a specific session that it occurred with Rat 33, independent of their responding. The intervals separating Rat 33's received shocks were determined from the cumulative records. Baseline conditions of stable weight and responding were maintained prior to any change of schedule values. Food allotment and session duration procedures were identical to those under conc FR AV conditions.

The ratio requirement was increased for Rats 21a and 35 from FR 10 by a factor of 1.2 for each session. Response independent shocks were delivered at the same temporal point in each session as they were received at each FR for Rat 33 in a specific ascending series under conc FR AV conditions. Once the ratio requirement reached the ratio at which Rat 33's FR response rate was below 10 per min, baseline responding was re-established under another conc FR 10 matched shock condition. Each time Rat 33 received a shock under one ascending series, a shock was delivered under that ascending series to the subject. In a fourth ascending series the ratio requirement was increased from FR 10 by a factor of 1.2 for each session to the ratio requirement at which the subject's response rate was below 10 per min (no shocks were delivered). For Rat 21a the FR alone ascending series was last, preceded by the matched 7.5 sec FR ascending series, 15 sec FR ascending series and 30 sec FR ascending series, in that order. For Rat 35 the FR alone FR ascending series was first, followed by the matched 15 sec FR ascending series, 30

sec FR ascending series and 7.5 sec FR ascending series, in that order.

Results

Figures 1, 2 and 3 show the overall response rate functions for the different ascending series under conc FR AV conditions (Figure 1), conc FR VIAV conditions (Figure 2) and matched shock conditions (Figure 3). Response rates were computed by dividing the total responses on one lever by the total minutes (including the reinforcement duration) in a session. The FR response rate first increased over sessions (and, thus over FR values), increasing to some peak, then decreased as the ratio requirement was increased further. A close examination of the cumulative records (see point "a" of Figures 4 and 5) and each session's overall shock rate (Table 2) show that the ratio requirement beyond which the FR response rate consistently decreased depended upon both the temporal pattern and rate of received shocks. When a rat received several shocks within a short period of time its FR response rate decreased during that time. Fixed-ratio response rates continued to decrease throughout the session and subsequent sessions once there were several increased shock periods within a session. In general, the shorter the RS or variable interval (either under avoidance or matched shock conditions) the earlier there were several increased shock periods within a session, and thus the earlier the decrease in the FR response rate. The similarity of the FR response rate functions under the various conditions (compare Figures 1, 2 and 3) suggests that received shocks have a similar affect on FR responding irrespective of concurrent avoidance

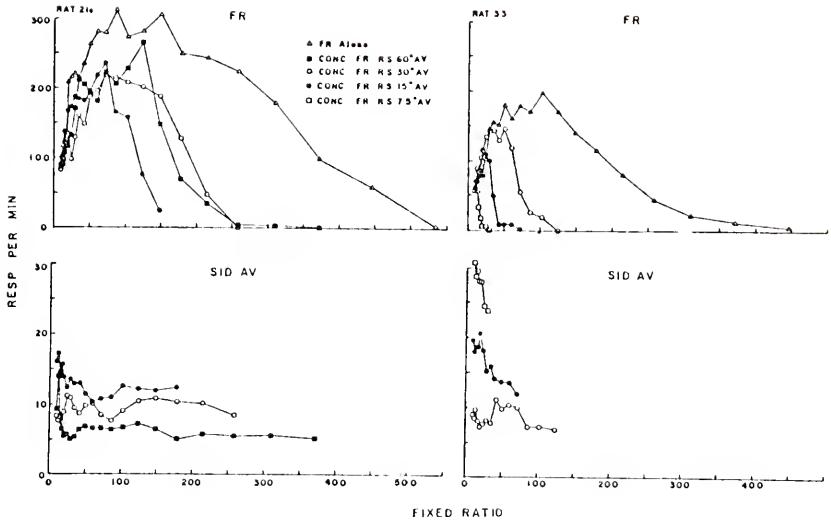


Figure 1. Rates of responding for Rat 21a (left side) and Rat 33 (right side) as a function of the FR requirement. Fixed-ratio response rates are shown in the top panels and AV response rates are shown in the bottom panels. Open triangles represent FR alone conditions, closed squares represent conc FR RS 60 sec AV conditions, open circles represent conc FR RS 30 sec AV conditions, closed circles represent conc FR RS 15 sec AV conditions, and open squares represent conc FR RS 7.5 sec AV conditions.

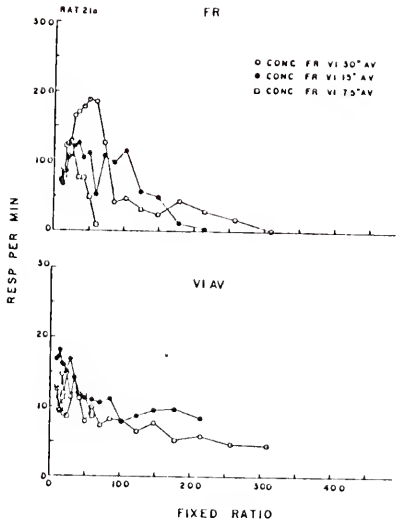


Figure 2. Rates of responding for Rat 21a as a function of the FR requirement. Fixed-ratio response rates are shown in the top panel, VIAV response rates are shown in the bottom panel. Open circles represent conc FR VI 30 sec AV conditions, closed circles represent conc FR VI 15 sec AV conditions, and open squares represent conc FR VI 7.5 sec AV conditions.

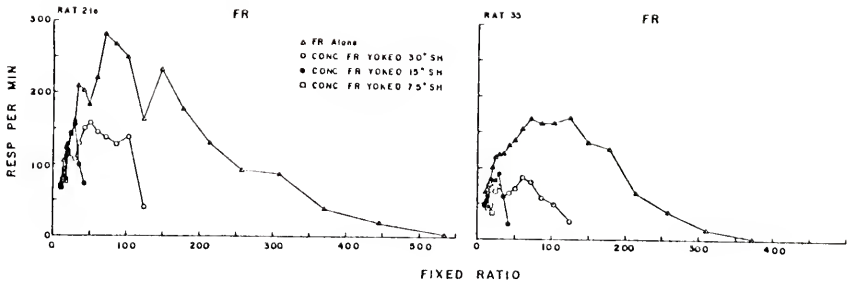


Figure 3. Rates of responding for Rat 21a (left side) and Rat 35 (right side) as a function of the FR requirement. Open triangles represent FR alone conditions, open circles represent conc FR Matched 30 sec SH conditions, closed circles represent conc FR Matched 15 sec SH conditions, and open squares represent conc FR Matched 7.5 sec SH conditions.

response contingencies.

Table 1 shows the mean time it took each subject to complete a ratio in each session under conc FR AV contingencies. The mean time to complete a ratio was determined by dividing the total number of FR reinforcers into the cumulative seconds spent from the first press on the FR lever after an avoidance response to the next press on the avoidance lever. Once the mean time to complete a ratio approximated the time permitted by the RS interval the shock rates generally increased (Table 2) and the FR response rate began to consistently decrease (Figure 1). The underlined points in Tables 1, 2 and 3 show the FR value at which the FR response rate decreased to approximately 50% of its maximum rate for each of the ascending series. Those ratio values were generally the same as or close to those sessions in which the mean time to complete a ratio approximated the time of the RS interval (Table 1) and the shock rate suddenly increased (Table 2). Changeovers generally decreased with the increase in ratio requirements (Table 3).

The overall Sidman and VI avoidance rate (bottom frames of Figures 1 and 2) for each session declined slightly with the concurrent ratio increases, even though a burst of AV responses frequently occurred after shock delivery, and shock frequency often increased (see Myer, 1975). Shock rates generally increased slightly with the higher ratio requirements. Avoidance response rates were highest with the shortest response-shock or variable interval and lowest with the longest response-shock or variable interval.

Figures 4 and 5 show cumulative response records of the first 50 minutes of sessions under various conc FR AV conditions. Fixed-

Table 1

Mean number of seconds to complete a ratio. The underlined times are the ratios to which the FR response rate decreased to approximately 50% of its maximum rate.

Rat 21a

Ratio	RS 60"	RS 30"	RS 15"	RS 7.5"	FR Alone
10	7.31	6.37	6.04		6.26
12	7.45	6.39	6.11		6.49
14	7.33	7.35	5.97		6.43
17	7.76	7.60	5.95		8.22
20	8.04	7.44	6.11		6.27
24	9.44	9.39	7.01		7.18
29	9.45	10.33	7.09		8.42
35	9.37	10.60	8.33		10.11
42	11.03	12.97	9.53		11.12
50	13.40	12.51	10.60		11.97
60	16.70	14.56	11.40		13.14
72	16.94	16.06	13.40		15.98
86	20.14	20.65	17.52		17.08
103	21.91	23.77	21.35		23.14
124	22.83	27.01	56.38		26.92
149	46.95	30.56	180.13		29.96
179	78.58	44.06	265.45		44.04
215	128.87	140.65			53.70
258	657.00	-			70.84
310	643.00				105.63
372	-				227.33
446					496.27
535					-

Rat 33

10		5.56	6.71	4.59	9.61
12		5.88	7.16	5.12	11.06
14		7.18	7.10	6.61	10.68
17		7.86	8.03	9.69	11.65
20		8.99	9.24	12.42	11.21
24		9.22	9.04	13.96	14.70
29		9.79	10.76	17.50	12.39
35		11.88	14.50		13.78
42		14.01	32.60		16.28

Table 1 (cont.)

Ratio	RS 60"	RS 30"	RS 15"	RS 7.5"	FR Alone
50		15.65	39.33		16.04
60		21.84	43.80		23.08
72		34.53	88.50		24.43
86		50.75			30.67
103		60.29			31.78
124		-			44.34
149					64.66
179					92.48
215					160.41

Table 2

Mean number of shocks per minute. The underlined values are the ratios to which the FR response rate decreased to approximately 50% of its maximum rate.

Rat 21a

Ratio	Sid AV 60"	Sid AV 30"	VIAV 30"	Sid AV 15"	VIAV 15"	Sid AV 7.5"	VIAV 7.5"
10	0.09	0.08	0.14	0.03	0.24		0.66
12	0.05	0.08	0.22	0.07	0.29		1.04
14	0.03	0.09	0.13	0.05	0.42		
17	0.08	0.11	0.16	0.08	0.32		0.68
20	0.07	0.08	0.19	0.03	0.31		0.59
24	0.07	0.18	0.05	0.23	0.32		0.98
29	0.07	0.10	0.19	0.10	0.44		2.04
35	0.05	0.07	0.23	0.10	0.42		1.18
42	0.03	0.14	0.22	0.15	0.41		1.28
50	0.09	0.07	0.30	0.14	0.52		1.56
60	0.09	0.12	0.27	0.16	0.53		2.04
72	0.09	0.04	0.41	0.10	0.61		
86	0.06	0.04	0.31	0.18	0.59		
103	0.07	0.08	0.36	0.21	0.61		
124	0.07	0.09	0.40	0.16	0.94		
149	0.21	0.08	0.36	0.18	0.71		
179	0.10	0.13	0.44	0.15	0.77		
215	0.06	0.14	0.44		1.01		
258	0.09	0.13	0.53				
310	0.10		0.36				
372	0.07						

Rat 33

10		0.16		0.07		0.15
12		0.15		0.09		0.14
14		0.13		0.09		0.32
17		0.21		0.11		0.32
20				0.13		0.27
24		0.16		0.09		
29		0.14		0.28		
35		0.17		0.44		
42		0.11		1.04		
50		0.11		0.61		

Table 2 (cont.)

Ratio	Sid AV 60"	Sid AV VIAV 30"	Sid AV VIAV 15"	Sid AV VIAV 7.5"
60		0.11	0.39	
72		0.17	0.62	
86		0.29		
103		0.24		
124		0.31		

Table 3

Mean number of changeovers per minute. The underlined values are the ratios to which the FR response rate decreased to approximately 50% of its maximum rate.

Rat 21a

Ratio	Sid AV 60"	Sid AV 30"	VIAV 30"	Sid AV 15"	VIAV 15"	Sid AV 7.5"	VIAV 7.5"
10	3.94	5.08	6.41	7.62	7.21		6.77
12	6.38	5.33	4.99	7.61	6.42		6.17
14	3.96	5.04	4.61	7.71	6.12		5.35
17	3.15	4.42	4.80	7.71	6.50		7.08
20	2.52	5.20	4.95	7.60	5.86		5.20
24	2.65	4.02	5.38	6.25	5.81		5.02
29	2.48	4.76	5.04	6.30	6.48		3.47
35	2.99	4.23	4.93	5.62	5.47		3.71
42	3.18	3134	4.22	5.66	11.22		3.03
50	3.01	4.31	3.43	4.97	8.67		2.77
60	2.62	3.93	3.94	4.64	10.94		1.53
72	3.15	4.15	2.87	4.25	3.47		
86	2.71	3.49	1.83	3.71	2.90		
103	2.60	3.32	2.28	4.47	2.56		
124	2.39	3.55	1.89	5.07	1.92		
149	2.41	2.79	1.36	4.59	2.42		
179	1.53	2.81	1.17	4.32	1.16		
215	1.28	3.36	0.92		0.88		
258	0.69	0.20	0.51				
310	0.62		0.36				
372	0.36						

Rat 33

10		5.20		5.81		5.69
12		5.27		5.81		5.81
14		4.57		5.75		3.87
17		4.36		5.18		2.67
20		3.33		4.60		1.11
24		4.13		5.34		0.98
29		4.62		4.41		0.30
35		3.88		2.84		
42		4.17		0.86		
50		4.08		1.04		
60		4.08		0.98		

Table 3 (cont.)

Ratio	Sid AV 60"	Sid AV VIAV 30"	Sid AV VIAV 15"	Sid AV VIAV 7.5"
72		2.64	0.57	
86		1.35	0.66	
103		1.17		
124		0.23		

ratio responding is shown on the left with the concurrent AV responding on the right. These response patterns were typical of the entire session. The top set of cumulative records (#1) show baseline responding (FR 10) for the conc FR RS 15 sec AV ascending series. At baseline conditions the subjects responded much like they did when responding to each schedule's contingencies alone. At an intermediate ratio requirement (#2) the subjects' pattern of AV responding remained similar to that of baseline conditions, while the AV rate of responding dropped slightly. The pattern of FR responding showed a little disruption in the beginning of the session (what looked like a warm-up effect typically seen in AV responding, e.g., Sidman, 1953), followed by a high rate of responding. At a high ratio requirement (#3) the subjects' pattern of AV responding again remained similar to that of baseline conditions while the overall rate of responding dropped further. The pattern of FR responding showed marked ratio strain throughout the session.

The effects of the avoidance RS interval on FR responding can be seen by comparing the three bottom FR cumulative records. Only one ratio requirement is presented (FR 72 for Rat 33 and FR 149 for Rat 21a) with a concurrent 15 sec AV schedule (#3), a concurrent RS 30 sec AV schedule (#4), or no concurrent schedule at all (#5). Depending on the concurrent avoidance requirement, the pattern of FR responding under a specific ratio requirement showed a marked decrease in responding, a slight decrease in responding, or no decrease in responding. Cumulative records of sessions under conc FR VIAV and FR matched shock conditions were quite similar to the ones presented.

Figure 4. Cumulative records of rates and patterns of responding by Rat 21a under conc FR AV and FR alone schedules. The records numbered 1, 2 and 3 are from three sessions in which the same RS interval was used (15 sec) with three different FR requirements (10, 72 and 149). The records numbered 4 and 5 are from two sessions in which the FR requirement was the same as that used in record #3 (FR 149) with either a longer RS interval (30 sec) or no concurrent avoidance schedule. Paper drive motors ran throughout sessions. Fixed-ratio records are on the left side, AV records are on the right side; changeovers are below the response records. Pips on the left response records indicate food delivery; pips on the right response records indicate shock delivery.

RAT 21a

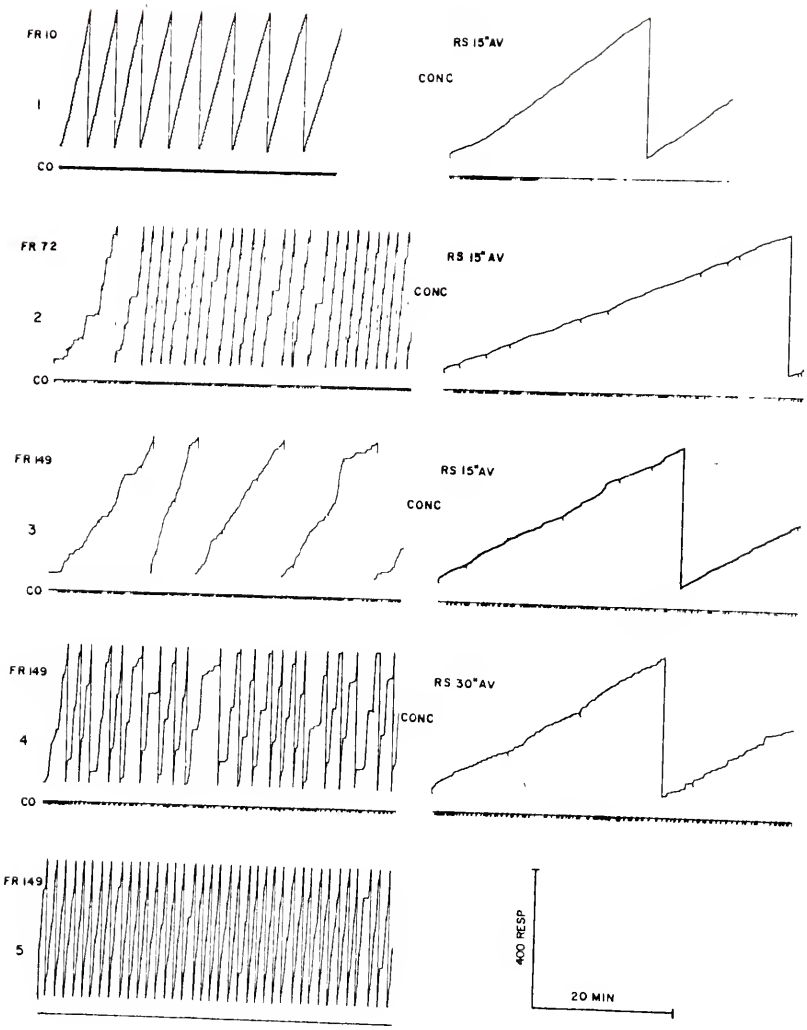
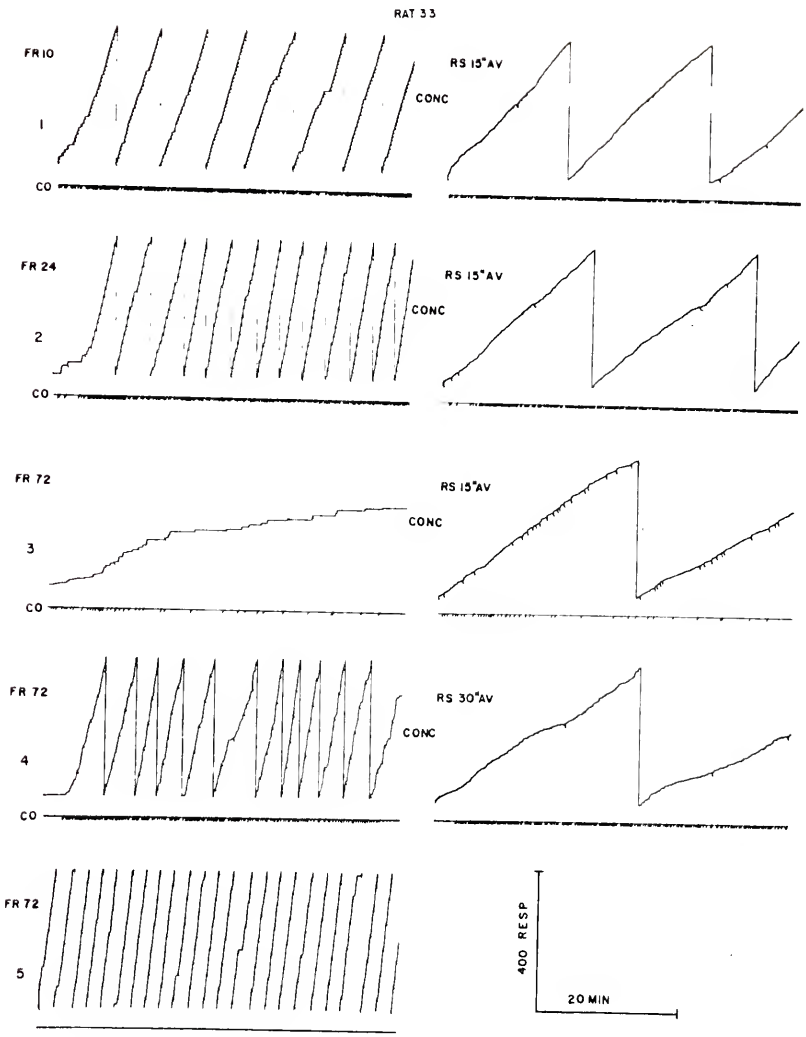

FR 10
1
CO
RS 15"AV
CONC
FR 72
2
CO
RS 15"AV
CONC
FR 149
3
CO
RS 15"AV
CONC
FR 149
4
CO
RS 30"AV
CONC
FR 149
5
400 RESP
20 MIN

Figure 5. Cumulative records of responding by Rat 33 under conc FR AV and FR alone conditions. The top three records (1, 2 and 3) are from three sessions in which the same RS interval was used (15 sec) with three different FR requirements (10, 24 and 72). The bottom two records (4 and 5) are from two sessions in which the FR requirement was the same as that used in record #3 (FR 72) with either a longer RS interval (30 sec) or no concurrent avoidance schedule.


RAT 33
FR 10
1
CO
CONC
RS 15"AV
FR 24
2
CO
CONC
RS 15"AV
FR 72
3
CO
CONC
RS 15"AV
FR 72
4
CO
CONC
RS 30"AV
FR 72
5
400 RESP
20 MIN

Discussion

The data presented here indicate that behavior maintained by an FR schedule can be affected by a concurrently programmed AV schedule. The extent of that effect is primarily determined by concurrent responding contingencies affecting the rate and temporal pattern of received shocks.

Though the procedures and subjects of the present experiment are different than those of the Catania, Deegan and Cook (1966) study, the results are comparable. In both studies FR and AV responding appear independent and, under certain conditions, have little or no effect on a subject's concurrent schedule response rate or pattern. The conditions when responding is affected appear to be when the time to complete a ratio is greater than the time allowed by the RS interval, usually resulting in an increase in shock density and a decrease in FR responding.

These data are also similar to conc FR FI studies using food and water as reinforcers (Wood, Martinez and Willis, 1975; Wood and Willis, 1974). As in this study FR response rates were inverted U shaped as a function of the size of the ratio requirement; FI response rates either showed no systematic effect as a function of ratio size (Wood, et al. 1975), or showed slight increases as the ratio requirement was increased (Wood and Willis, 1974). These similarities strongly suggest that behaviors maintained by different reinforcers are different from behaviors maintained by the same rein-

forcer. Such results may have serious implications for previous generalizations taken from controlled animal research. Responding for a specific reinforcer is effected by concurrent contingencies, especially if they involve aversive events. Further research should investigate behavior to various schedules maintained by different reinforcers.

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Appendix

Rat 33, conc FR RS 7.5 sec conditions

Ratio Value	FR Resp.	AV Resp.	FR Reinf.	Shocks	C.O.	Mins.
10	3852	2080	360	10	383	67.5
12	4497	2193	355	11	443	76.2
14	2967	2663	206	29	348	90.0
17	1459	2265	85	26	215	80.4
20	635	2530	31	24	100	90.0
24	634	2207	26	25	88	90.0
29	181	2145	6	22	27	90.1

Rat 33, conc FR RS 15 sec conditions

10	3701	1169	340	4	347	59.7
12	4457	1143	345	6	368	63.3
14	5147	1236	346	6	380	66.1
17	6429	1364	350	8	380	73.3
20	4737	2355	225	8	279	60.7
24	8928	1474	355	7	433	81.1
29	9142	1362	303	25	400	90.7
35	4775	1486	133	41	264	93.1
42	879	1262	20	93	77	89.5
50	912	1230	18	55	94	90.0
60	955	1225	15	35	88	90.0
72	304	1082	4	56	51	90.1

Rat 33, conc FR RS 30 sec conditions

Ratio Value	FR Resp.	AV Resp.	FR Reinf.	Shocks	C.O.	Mins.
10	3978	500	360	9	286	55.0
12	4695	443	360	8	272	51.8
14	5420	607	360	8	281	62.5
17	6424	492	360	13	266	61.0
20	7613	480	360	--	218	65.5
24	9069	510	360	11	277	67.0
29	10855	627	360	11	353	76.4
35	13115	709	360	15	353	90.9
42	12236	1052	284	10	393	94.2
50	13126	886	257	10	367	89.9
60	10948	954	180	10	373	91.5
72	4850	901	66	15	238	90.0
86	2450	662	28	26	122	90.1
103	1812	659	17	22	105	90.1
124	88	580	0	26	19	83.5

Rat 33, FR Alone conditions

10	3730		369			59.1
12	4407		332			61.2
14	5276		340			60.5
17	6285		342			66.4
20	7246		340			63.5
24	9160		365			89.4
29	10252		340			70.2
35	11192		313			71.9

Rat 33, FR Alone conditions (continued)

Ratio Value	FR Resp.	AV Resp.	FR Reinf.	Shocks	C.O.	Mins.
42	14267		327			94.2
50	16885		352			94.1
60	14301		235			90.4
72	16392		225			91.6
86	15709		180			92.0
103	18312		175			92.7
124	15490		123			90.9
149	12845		85			91.6
179	10425		58			89.4
215	7336		34			90.9
258	3982		15			90.1
310	2065		6			91.5
372	1200		3			91.3
446	579		1			91.8

Rat 21a, conc FR RS 15 sec conditions

10	3562	577	325	1	307	40.3
12	4176	740	325	3	324	42.6
14	4935	581	325	2	310	40.1
17	6586	748	367	4	355	47.6
20	6815	563	320	1	308	40.5
24	8198	583	320	11	293	46.9
29	9445	683	310	5	315	50.0
35	11033	767	300	6	334	59.4
42	13560	969	310	11	419	74.1
50	15495	900	300	11	392	78.9

Rat 21a, conc FR RS 15 sec conditions (continued)

Ratio Value	FR Resp.	AV Resp.	FR Reinf.	Shocks	C.O.	Mins.
60	18635	886	302	14	396	85.4
72	23691	1087	315	10	426	100.3
86	14757	1161	139	19	411	91.8
103	14644	1161	139	19	411	91.8
124	6999	1010	55	14	458	90.3
149	2428	896	16	18	413	90.2
179	2126	945	11	14	390	90.2

Rat 21a, conc FR RS 30 sec conditions

10	3274	332	320	3	199	39.3
12	3956	308	320	3	212	39.8
14	4602	437	320	4	236	47.0
17	5528	347	320	5	207	46.8
20	6503	427	320	4	250	48.1
24	7805	890	321	14	318	79.1
29	9383	792	320	7	346	72.7
35	11391	672	320	5	298	70.5
42	13718	812	320	13	309	92.4
50	16327	861	320	6	378	87.7
60	18626	962	300	11	372	95.0
72	20076	875	270	4	381	91.8
86	19479	701	215	4	316	90.5
103	18916	831	181	7	301	90.7
124	18003	831	137	8	317	89.2
149	16359	937	104	7	255	91.5
179	11689	950	62	12	256	91.1

Rat 21a, conc FR RS 30 sec conditions (continued)

Ratio Value	FR Resp.	AV Resp.	FR Reinf.	Shocks	C.O.	Mins.
215	4534	953	20	13	313	93.2
258	61	778	0	12	18	91.0

Rat 21a, conc FR RS 60 sec conditions

10	2484	297	230	3	124	31.5
12	3245	553	255	2	250	39.2
14	3505	266	235	1	128	32.3
17	4205	236	235	3	113	35.9
20	5445	243	255	3	111	44.0
24	6265	274	247	3	124	46.8
29	7441	223	244	3	108	43.5
35	9385	239	255	2	132	44.2
42	12219	390	280	2	189	59.4
50	12158	447	235	6	194	64.5
60	15536	594	251	8	237	90.6
72	19953	589	270	8	281	89.1
86	18581	582	212	5	244	90.0
103	20687	608	196	6	234	90.1
124	23983	661	189	6	215	90.1
149*	11271	551	74	10	157	90.2
149	13153	586	86	19	217	90.1
179	7132	513	38	10	154	90.7
215	3356	543	15	6	119	93.3
258	405	495	1	8	62	90.3
310	401	507	1	9	56	90.1
372	105	316	0	4	22	60.3

Rat 21a, FR Alone conditions

Ratio Value	FR Resp.	FR Reinf.	Mins.
10	3395	305	32.1
12	3834	311	32.7
14	4491	300	32.5
17	5345	300	41.4
20	6708	305	32.1
24	7964	305	36.8
29	9749	308	44.1
35	12106	332	56.2
42	14667	330	62.2
50	17045	323	64.7
60	20039	323	71.1
72	25201	337	90.3
86	28375	317	90.7
103	25507	241	93.4
124	26066	205	92.5
149	27982	182	91.4
179	22785	124	91.5
215	21933	100	89.9
258	20556	77	91.4
310	16159	51	90.2
372	9116	24	91.4
446	5397	11	91.4
535	328	0	91.2

Rat 21a, conc FR VI 7.5 sec AV conditions

Ratio Value	FR Resp.	AV Resp.	FR Reinf.	Shocks	C.O.	Mins.
10	4143	708	377	37	379	56.0
12	6012	638	456	68	404	65.5
14	6247	742	413	112	426	79.7
17	7903	729	430	44	456	64.4
20	9035	650	423	43	378	72.7
24	10739	729	420	82	422	84.0
29						
35	6960	1131	187	108	340	91.7
42	6984	1020	157	117	277	91.5
50	4517	1040	86	143	254	91.8
60	821	760	13	180	135	88.1

Rat 21a, conc FR VI 15 sec AV conditions

10	2909	707	262	10	302	41.9
12	3883	941	300	16	353	55.0
14	5194	1195	350	28	405	66.2
17	8523	1327	480	26	535	82.5
20	7287	1122	332	22	412	70.3
24	9307	1288	362	28	500	86.0
29	10357	1423	337	38	549	84.7
35	11554	1310	312	39	505	92.3
42	9419	1098	216	38	1036	92.3
50	10031	1016	193	47	780	90.0
60	4709	985	75	48	985	90.0
72	12129	1100	160	53	312	90.0

Rat 21a, conc FR VI 15 sec AV conditions (continued)

Ratio Value	FR Resp.	AV Resp.	FR Reinf.	Shocks	C.O.	Mins.
86	8859	1003	97	55	261	90.0
103	8299	560	77	67	183	71.6
124	5178	792	40	73	175	91.1
149	4536	874	29	65	221	91.3
179	1150	877	6	70	106	91.5
215	420	754	1	91	79	90.0

Rat 21a, conc FR VI 30 sec AV conditions

10	4685	825	437	9	411	64.1
12	4907	816	387	16	363	72.7
14	5740	629	380	9	310	67.3
17	6916	1175	381	13	383	79.8
20	7326	813	340	13	339	68.5
24	8666	987	340	10	357	66.4
29	10981	757	357	13	337	66.8
35	12751	1065	345	17	369	74.8
42	13716	853	311	15	324	76.8
50	17172	720	324	27	313	91.2
60	16670	892	268	24	354	89.8
72	11525	673	156	37	261	91.1
86	3758	746	42	28	166	90.8
103	4245	737	44	33	208	91.2
124	2781	595	22	37	173	91.5
149	2125	707	14	33	124	91.4
179	3998	476	22	40	107	91.1

Rat 21a, conc FR VI 30 sec AV conditions (continued)

Ratio Value	FR Resp.	AV Resp.	FR Reinf.	Shocks	C.O.	Mins.
215	2621	530	12	40	84	91.1
258	1605	430	6	48	47	91.4
310	199	417	0	43	33	91.5
Rat 21a, FR Yoked 7.5 sec SH conditions						
10	4363		395	10		65.7
12	5377		412	8		69.1
14	6140		402	17		69.7
17	6876		380	25		90.5
20	8256		388	19		69.3
Rat 21a, FR Yoked 15 sec SH conditions						
10*	3910		351	5		65.7
12*	4235		336	6		63.0
10	4302		411	4		58.2
12	5095		414	5		56.2
14	5772		407	6		70.1
17	7357		425	7		65.8
20	8473		418	7		66.3
24	10178		422	7		71.1
29						
35	9008		255	41		90.9
42	6906		162	86		94.2
Rat 21a, FR Yoked 30 sec SH conditions						
10	4471		431	8		64.0
12	4497		364	9		59.7

Rat 21a, FR Yoked 30 sec SH conditions (continued)

Ratio Value	FR Resp.	FR Reinf.	Shocks	Mins.
14	6067	425	7	65.0
17	7286	423	13	83.0
20	7885	388	10	74.8
24	3783	156	12	53.6
29	4975	170	5	46.3
35	6469	184	4	50.8
42	12791	303	9	85.2
50	13942	278	9	88.2
60	12294	204	7	85.0
72	12557	173	15	90.8
86	11575	134	19	90.3
103	12480	121	20	90.5
124	3446	28	26	85.2

Rat 21a, FR Alone conditions

10	4569	428		62.1
12	4939	385		60.3
14	4108	277		39.1
17	7849	442		63.6
20	8323	401		69.5
24	11174	444		78.7
29	12841	426		79.8
35	16110	440		79.8
42	19611	451		96.7
50	14990	292		82.3

Rat 21a, FR Alone conditions (continued)

Ratio Value	FR Resp.	FR Reinf.	Shocks	Mins.
60	19849	321		90.1
72	25327	342		90.0
86	24487	275		90.1
103	21534	203		86.6
124	14394	114		88.5
149	21246	140		91.4
179	15809	87		89.2
215	10958	50		84.3
258	8382	32		90.4
310	7887	25		90.0
372	2333	6		60.8
446	1994	4		104.0
535	409	0		103.2
Rat 35, FR Yoked 7.5 sec SH conditions				
10	3513	344	10	70.7
12	4225	343	11	87.1
14	3846	267	22	90.3
17	3460	199	15	72.0
20	3363	163	24	90.0
Rat 35, FR Yoked 15 sec SH conditions				
10	3624	353	4	72.9
12	4248	340	3	78.7
14	5147	360	7	86.2
17	6234	356	7	81.5

Rat 35, FR Yoked 15 sec SH conditions (continued)

Ratio Value	FR Resp.	FR Reinf.	Shocks	Mins.
20	7057	345	6	84.4
24	7592	314	7	91.9
29	8525	287	23	92.4
35	5635	159	37	93.0
42	2027	47	80	93.1

Rat 35, FR Yoked 30 sec SH conditions

10	3480	334	5	73.7
12	3096	251	8	60.9
14	4260	296	7	65.6
17	4884	285	9	70.2
20	6332	312	13	77.1
24	5616	231	11	84.5
29	6342	216	11	85.0
35	5259	148	14	87.1
42	5979	141	9	91.5
50	6590	130	9	91.8
60	4776	79	4	55.2
72	7248	99	14	90.2
86	5167	59	21	88.8
103	4483	43	20	90.0
124	2312	18	27	90.0

Rat 35, FR Alone conditions

10	4218	380		57.9
12	4150	321		58.5

Rat 35, FR Alone conditions (continued)

Ratio Value	FR Resp.	FR Reinf.	Mins.
14	4263	283	55.2
17	5457	303	64.6
20	7942	380	78.9
24	7406	294	64.0
29	8636	284	72.9
35	10282	284	85.6
42	9604	219	73.0
50	13384	257	90.0
60	14045	228	90.8
72	15226	207	90.3
86	14598	164	90.0
103	14598	138	90.0
124	15326	121	90.1
149	12780	84	93.9
179	11485	63	90.5
215	5938	27	90.4
258	3530	13	90.0
310	1389	4	90.0
372	156	0	90.9

Biographical Sketch

Keith Anthony Wood was born on October 25, 1949 in Washington D.C. He did his undergraduate work in psychology at Oakwood College from which he graduated in 1971. He did his graduate work in psychology at the University of Florida from which he earned his master's in 1973. He completed a clinical psychology internship at the University of Washington Medical School in 1976.