

THE RESISTANCE TO CHANGE OF OBSERVING

TIMOTHY A. SHAHAN, ADAM MAGEE, AND ANDRIA DOBBERSTEIN

UTAH STATE UNIVERSITY AND UNIVERSITY OF NEW HAMPSHIRE

Observing responses produce contact with discriminative stimuli and have been considered analogous to attending. Many studies have examined the effects of reinforcement rate on the resistance to change of simple operant behavior, but nothing is known about the resistance to change of observing. Two experiments examined the effects of primary reinforcement rate on the resistance to change of observing behavior of pigeons. In Experiment 1, a multiple schedule of observing-response procedures was arranged. In a rich component, observing responses produced stimuli correlated with a high rate of random-interval (RI) reinforcement or extinction. In a lean component, observing responses produced stimuli correlated with a lower rate of RI reinforcement or extinction. In both components, observing responses produced the multiple-schedule stimuli on a fixed-interval 0.75-s schedule. In Experiment 2, a similar procedure was used, but observing in the rich and lean components produced schedule-correlated stimuli on an RI 15-s schedule. Observing in the rich component occurred at a higher rate and was more resistant to disruptions produced by pre-session feeding and response-independent food deliveries during intercomponent intervals. Despite more frequent observing during unsignaled periods of extinction than unsignaled periods of RI reinforcement, observing during extinction periods was less resistant to change. In addition, replicating the usual result, responding on the food key was generally more resistant to change in the presence of stimuli associated with higher reinforcement rates. These results suggest that quantitative descriptions of resistance to change derived with simple food-maintained responding may be applicable to observing, and perhaps by extension, to attending.

Key words: observing, resistance to change, reinforcement rate, conditioned reinforcement, attention, key peck, pigeon

Observing responses (e.g., looking, listening, sniffing, touching, tasting) bring sensory receptors into contact with environmental stimuli to be discriminated (Wyckoff, 1952). Observing has been suggested as an analog of attending and has been considered critical to an understanding of stimulus control (e.g., Dinsmoor, 1985; see also McIlvane, Dube, & Callahan, 1996, for discussion). Various theoretical accounts of stimulus control include a role for attending (Church & Gibbon, 1982; Heineman, Avin, Sullivan, & Chase, 1969; Lovejoy, 1965; Mackintosh, 1975; Zeaman & House, 1963). In many of these models, failures of stimulus control are attributed to lapses of attention (see Blough, 1996, for discussion). To the extent that measured observing is analogous to hypothesized attending, understanding variables that affect the persistence of observing could be useful in the con-

struction of such theories. Although inferring lapses of attention from measures of stimulus control and also using attention to explain these measures may be dubious, it nevertheless seems difficult to exclude observing/attending from a complete account of stimulus control (cf. Dinsmoor, 1985). The experiments reported here begin an analysis of variables affecting the resistance to change of observing.

In the typical procedure for studying observing responses (Wyckoff, 1952), unsignaled periods of access to a schedule of primary reinforcement alternate with unsignaled periods of extinction (i.e., a mixed schedule). Observing responses produce brief periods of access to stimuli correlated with the alternating reinforcement (S+) and extinction (S-) periods (i.e., a multiple schedule), but do not alter the availability of the primary reinforcer. Observing responses appear to be maintained because they produce the improved stimulus-reinforcer relation defined by S+ presentations (i.e., by the conditioned reinforcing effects of S+ presentations; for reviews, see Dinsmoor, 1983; Fantino, 1977).

A common finding in the study of the resistance to change of responding in multiple

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Requests for reprints should be addressed to Timothy A. Shahan, Department of Psychology, Utah State University, 487 Old Main Hill, Logan, Utah 84322 (e-mail: Tim.Shahan@usu.edu).

schedules is that behavior occurring in the presence of a stimulus associated with more frequent or larger reinforcers is more resistant to disruption (for reviews, see Nevin, 1992; Nevin & Grace, 2000). Resistance to change is measured by introducing a disrupter (e.g., pre-session feeding, extinction, inter-component food) and examining the resulting decrease in response rates relative to the baseline. Relatively smaller decreases from baseline reflect behavior that is more resistant to change. According to behavioral momentum theory (Nevin, 1992; Nevin & Grace, 2000; Nevin, Mandell, & Atak, 1983), resistance to change (i.e., response strength) is a reflection of a mass-like aspect of behavior that is modulated by the stimulus-reinforcer relation. Furthermore, Grace and Nevin (1997) noted that the conditioned reinforcing value of a stimulus-reinforcer context and the resistance to change of responding in that context were positively related. This relation was obtained using a procedure in which concurrent-chains schedules and a multiple schedule were arranged in the same session. The stimuli and schedules in the multiple schedule were the same as those in the terminal links of the concurrent chains. Preference in the initial links of the concurrent chains depended on relative reinforcement rate. Similarly, when the multiple-schedule performance was separately disrupted, resistance to change of responding in the presence of the stimuli depended on relative reinforcement rate. Although both preference for a context and the resistance to change of responding in that context were modulated by the stimulus-reinforcer relation, Grace and Nevin did not examine whether responding that produces a relatively greater improvement in the stimulus-reinforcer context is more resistant to change.

The resistance to change of responding that produces access to differential stimulus-reinforcer contexts has been examined, however, with simple chain schedules (e.g., Mellon & Shull, 1986; Nevin, Mandell, & Yarensky, 1981). For example, Nevin *et al.* examined the resistance to change of pigeons' responding in a multiple schedule of two-link random-interval (RI) chain schedules. In the multiple-chain schedule, two chain RI schedules alternated irregularly on different keys and were associated with different stim-

uli. The initial links of the two chain schedules were equal (i.e., RI 40 s), but durations of the terminal links (i.e., rate of reinforcement) and magnitude of the primary reinforcer were varied across conditions. Replicating previous work in simple multiple schedules, responding in the richer terminal link was more resistant to pre-session feeding than responding in the leaner terminal link. In addition, and most important for present purposes, responding in the initial link providing access to the richer terminal link was more resistant to pre-feeding than responding in the initial link providing access to the leaner terminal link. Thus responding that produced access to a context defined by a relatively better stimulus-reinforcer relation (i.e., a conditioned reinforcer of greater value) was more resistant to change.

One potential shortcoming of examining the persistence of behavior maintained by conditioned reinforcement with chain schedules is the dependency between completion of the initial link and access to the primary reinforcer in the terminal link. This dependency is a generally recognized complication associated with using chained schedules to study conditioned reinforcement (Branch, 1983; Dinsmoor, 1983; Williams, 1994). The observing-response procedure avoids this complication by not requiring observing responses for the delivery of the primary reinforcer. In addition to this potential advantage, the persistence of observing behavior is interesting in its own right given its conceptual links to attending and stimulus control.

The present experiments examined the persistence of pigeons' observing behavior by arranging a multiple schedule of observing-response procedures. Each component arranged an independent observing-response procedure using different stimuli. In the rich component, observing responses produced stimuli correlated with alternating periods of an RI 15-s schedule of reinforcement and extinction. In the lean component, observing responses produced access to stimuli correlated with alternating periods of an RI 60-s schedule of reinforcement and extinction. In Experiment 1, observing was maintained on a fixed-interval (FI) 0.75-s schedule of reinforcement and the disruptive effects of different pre-session feeding amounts were examined. In Experiment 2, observing was

maintained on an RI 15-s schedule of reinforcement in both components and the schedules of primary reinforcement were changed to RI 30 s and RI 120 s in the rich and lean components, respectively. The disruptive effects of 5-day blocks of pre-session feeding and intercomponent food were then examined.

EXPERIMENT 1

METHOD

Subjects

The subjects were 4 White Carneau pigeons maintained at approximately 80% of their free feeding weights (± 15 grams) by postsession feeding as necessary. Pigeons 77, 210, 79, and 123 weighed 477 g, 410 g, 465 g, and 440 g, respectively. The pigeons varied in age and had extensive experience in other experiments. When not in experimental sessions, the pigeons were housed in individual cages in a temperature-controlled colony with a 12:12 hr light/dark cycle (lights on at 6:00 a.m.) and had free access to digestive grit and water in their home cages.

Apparatus

The experiment was conducted in four Lehigh Valley Electronics pigeon chambers measuring 35 cm long, 35 cm high, and 30 cm wide. Three response keys were located on the front panel 24 cm above the floor. The keys measured 2.5 cm in diameter and required a force of about 0.1 N to operate. A projector could transilluminate each key red, green, blue, yellow, or with three parallel black lines on a white background. Line orientations varying from vertical to horizontal in 22.5° increments could be presented. Reinforcement consisted of 2-s presentations of pigeon checkers from a hopper. The hopper was accessible, when raised, through a 5 cm wide by 5.5 cm tall aperture located on the midline of the work panel with its center 10 cm from the floor. A 28-V DC clear bulb illuminated the aperture and all other lights were extinguished when the hopper was operated. General illumination was provided by a shielded 28-V DC clear bulb mounted 4.5 cm above the center key. A ventilation fan and white noise masked extraneous sounds. Control of experimental events and data re-

coding were conducted with Med Associates (1999) programming and interfacing.

Procedure

Multiple-schedule training. Initially, subjects were trained on a multiple schedule of reinforcement in which each component was also a multiple schedule. One component of the multiple schedule of multiple schedules was designated the rich component and the other was designated the lean component. The rich and lean components alternated every 10 min (exclusive of reinforcement time) and were separated by a 30-s intercomponent blackout. The first component (i.e., rich or lean) was chosen randomly. Sessions consisted of two exposures to each 10-min component. All schedules were arranged and their stimuli were presented on the center key. In the rich component, an RI 15-s schedule alternated with extinction. In the lean component, an RI 60-s schedule alternated with extinction. For Pigeons 77 and 210, green signaled the RI 15-s schedule during the rich component and blue signaled extinction. During the lean component, yellow signaled the RI 60-s schedule and red signaled extinction. For Pigeons 79 and 123, yellow and blue signaled the RI and extinction schedules in the rich component, and green and red signaled the RI and extinction schedules in the lean component. In both the rich and lean components, the RI and extinction schedules alternated after variable times averaging 60 s, with component durations ranging from 10 to 110 s in 10-s increments. The RI schedules in both the rich and lean components were arranged by sampling a probability gate every 0.75 s with the appropriate probability. Reinforcers arranged by an RI schedule but not delivered were held until the RI was presented again within a particular rich or lean component, but were canceled with transitions between the rich and lean components. Each pigeon continued training until approximately 80% of all responding occurred during the RI component in both the rich and lean components. Multiple schedule training lasted 34, 14, 30, and 29 sessions for Pigeons 77, 210, 79, and 123, respectively.

Observing-response procedures. Following multiple-schedule training, a multiple schedule of observing-response procedures was introduced. The rich and lean components and

Table 1

Sessions in each baseline (BL) preceding each disrupter, mean and standard deviation (in parentheses) total percentage of available time spent in the presence of schedule correlated stimuli, percentage of time spent in S+ and S−, food-key responses per minute during S− presentations, and observing rates during RI and extinction components during the mixed schedule for the last five sessions of each baseline and each session of the disrupter for the rich and lean components.

Subject	Condition	Sessions	Percentage of available time					
			Rich			Lean		
			Total	S+	S−	Total	S+	S−
P77	5% BL	16	0.91	0.45	0.47	0.88	0.45	0.43
			(0.01)	(0.06)	(0.06)	(0.01)	(0.07)	(0.07)
	5%		0.92	0.39	0.53	0.87	0.43	0.44
			(0.00)	(0.05)	(0.06)	(0.01)	(0.06)	(0.06)
	10% BL	20	0.92	0.42	0.50	0.89	0.42	0.46
			(0.00)	(0.05)	(0.06)	(0.01)	(0.06)	(0.06)
	10%		0.82	0.40	0.42	0.57	0.32	0.26
			(0.00)	(0.05)	(0.06)	(0.01)	(0.06)	(0.06)
	15% BL	15	0.92	0.44	0.48	0.81	0.38	0.43
			(0.01)	(0.05)	(0.06)	(0.02)	(0.04)	(0.05)
15%		0.85	0.49	0.36	0.52	0.31	0.21	
		(0.01)	(0.05)	(0.06)	(0.02)	(0.04)	(0.05)	
10% BL	54	0.93	0.47	0.45	0.81	0.36	0.45	
		(0.00)	(0.10)	(0.10)	(0.03)	(0.06)	(0.07)	
10%		0.90	0.53	0.37	0.76	0.37	0.39	
		(0.00)	(0.10)	(0.10)	(0.03)	(0.06)	(0.07)	
P210	5% BL	18	0.85	0.42	0.43	0.86	0.42	0.43
			(0.01)	(0.04)	(0.04)	(0.02)	(0.06)	(0.07)
	5%		0.84	0.43	0.41	0.77	0.37	0.40
			(0.01)	(0.04)	(0.04)	(0.02)	(0.06)	(0.07)
	10% BL	6	0.86	0.43	0.43	0.83	0.40	0.43
			(0.00)	(0.04)	(0.04)	(0.01)	(0.04)	(0.04)
	10%		0.73	0.38	0.35	0.10	0.06	0.04
			(0.00)	(0.04)	(0.04)	(0.01)	(0.04)	(0.04)
	15% BL	41	0.85	0.35	0.50	0.73	0.39	0.34
			(0.01)	(0.02)	(0.02)	(0.07)	(0.06)	(0.07)
15%		0.73	0.34	0.40	0.04	0.03	0.01	
		(0.01)	(0.02)	(0.02)	(0.07)	(0.06)	(0.07)	
15% BL	59	0.70	0.27	0.42	0.60	0.27	0.33	
		(0.07)	(0.06)	(0.06)	(0.09)	(0.07)	(0.07)	
15%		0.32	0.16	0.16	0.01	0.00	0.01	
		(0.07)	(0.06)	(0.06)	(0.09)	(0.07)	(0.07)	
P79	5% BL	27	0.64	0.22	0.42	0.30	0.13	0.17
			(0.08)	(0.02)	(0.10)	(0.04)	(0.04)	(0.03)
	5%		0.56	0.22	0.34	0.34	0.17	0.17
			(0.08)	(0.02)	(0.10)	(0.04)	(0.04)	(0.03)
	10% BL	80	0.55	0.20	0.35	0.53	0.19	0.34
			(0.07)	(0.02)	(0.07)	(0.10)	(0.03)	(0.11)
	10%		0.56	0.13	0.43	0.49	0.20	0.30
			(0.07)	(0.02)	(0.07)	(0.10)	(0.03)	(0.11)
	15% BL	23	0.54	0.20	0.34	0.49	0.18	0.31
			(0.08)	(0.06)	(0.05)	(0.02)	(0.01)	(0.03)
15%		0.55	0.23	0.31	0.39	0.17	0.22	
		(0.08)	(0.06)	(0.05)	(0.02)	(0.01)	(0.03)	
10% BL	18	0.59	0.22	0.37	0.56	0.22	0.34	
		(0.07)	(0.04)	(0.09)	(0.03)	(0.05)	(0.06)	
10%		0.57	0.35	0.22	0.45	0.24	0.21	
		(0.07)	(0.04)	(0.09)	(0.03)	(0.05)	(0.06)	
P123	5% BL	21	0.91	0.41	0.50	0.87	0.42	0.45
			(0.00)	(0.09)	(0.05)	(0.01)	(0.09)	(0.09)
	5%		0.90	0.40	0.50	0.86	0.37	0.49
			(0.00)	(0.09)	(0.05)	(0.01)	(0.09)	(0.09)
	10% BL	41	0.91	0.43	0.48	0.82	0.40	0.43
			(0.01)	(0.09)	(0.08)	(0.03)	(0.04)	(0.04)
	10%		0.81	0.54	0.27	0.51	0.20	0.31
			(0.01)	(0.09)	(0.08)	(0.03)	(0.04)	(0.04)
	15% BL	81	0.89	0.48	0.41	0.85	0.43	0.42
			(0.01)	(0.09)	(0.09)	(0.01)	(0.06)	(0.06)
15%		0.00	0.00	0.00	0.04	0.01	0.02	
		(0.01)	(0.09)	(0.09)	(0.01)	(0.06)	(0.06)	
15% BL	36	0.89	0.47	0.41	0.85	0.36	0.48	
		(0.01)	(0.05)	(0.05)	(0.01)	(0.08)	(0.08)	
15%		0.47	0.28	0.19	0.24	0.17	0.07	
		(0.01)	(0.05)	(0.05)	(0.01)	(0.08)	(0.08)	

Table 1
(Extended)

S-food-key responses per minute		Observing rates mixed			
		Rich		Lean	
Rich	Lean	RI	Extinction	RI	Extinction
2.73	0.40	45.02	72.90	32.35	33.27
(0.66)	(0.27)	(4.58)	(21.71)	(2.29)	(8.17)
0.85	0.34	40.59	75.77	22.92	40.24
4.20	3.02	45.27	69.52	29.44	40.26
(1.83)	(4.14)	(6.37)	(2.36)	(6.08)	(2.36)
0.36	0.00	26.40	14.25	6.05	4.75
1.87	0.36	48.16	57.09	14.96	22.71
(1.769)	(0.25)	(5.03)	(11.92)	(1.92)	(3.85)
0.27	0.00	26.52	21.78	5.58	3.37
1.95	0.40	57.75	86.63	14.16	30.91
(0.90)	(0.30)	(4.51)	(16.84)	(3.82)	(7.24)
0.81	0.00	32.24	43.09	11.52	14.56
0.21	0.04	20.35	31.72	22.14	27.83
(0.28)	(0.09)	(3.99)	(5.88)	(3.78)	(6.51)
0.00	0.25	21.63	23.54	11.89	16.41
0.14	0.09	21.98	31.27	18.50	23.61
(0.13)	(0.05)	(0.92)	(4.09)	(1.87)	(3.06)
0.00	0.00	11.93	10.59	0.44	0.45
0.08	0.06	16.56	32.91	9.48	19.58
(0.08)	(0.08)	(2.18)	(3.02)	(3.82)	(6.63)
0.00	0.00	13.09	10.44	0.21	0.11
0.02	0.14	6.05	20.78	4.50	10.89
(0.05)	(0.15)	(2.44)	(5.33)	(1.74)	(5.25)
0.00	0.00	1.74	2.37	0.00	0.10
4.87	12.83	3.66	16.42	1.48	2.28
(2.52)	(8.65)	(0.95)	(4.78)	(0.44)	(0.48)
2.03	20.15	3.00	11.83	1.66	3.66
0.27	2.05	2.41	15.14	2.43	10.57
(0.20)	(3.18)	(0.56)	(5.00)	(0.54)	(5.28)
0.69	6.85	1.07	15.72	1.99	7.47
0.14	0.20	2.77	11.89	2.08	7.98
(0.16)	(0.10)	(1.30)	(2.72)	(0.55)	(3.24)
0.00	0.00	3.69	7.01	3.00	2.64
0.23	1.22	2.90	15.36	2.91	12.43
(0.20)	(1.69)	(0.79)	(4.69)	(0.42)	(4.45)
0.22	0.00	4.90	8.64	3.20	4.57
0.68	0.53	58.80	47.47	27.19	30.53
(0.37)	(0.17)	(9.48)	(7.83)	(5.31)	(4.52)
2.80	0.41	47.89	44.54	22.13	25.97
1.26	0.79	70.69	60.43	18.60	21.94
(0.72)	(0.57)	(7.55)	(17.73)	(3.83)	(5.66)
1.89	0.97	20.89	14.13	3.57	5.17
1.14	0.60	56.15	25.34	22.27	32.40
(1.22)	(0.39)	(3.35)	(3.61)	(1.64)	(5.14)
0.00	41.62	0.00	0.00	0.21	0.10
0.43	0.39	47.00	25.11	19.61	25.80
(0.23)	(0.38)	(2.83)	(3.68)	(1.62)	(3.30)
7.46	3.05	3.42	4.35	1.67	0.73

the RI extinction multiple-schedule components within them continued as programmed in multiple-schedule training. The stimuli associated with the RI and extinction components, however, were replaced by nondifferential mixed-schedule stimuli on the center (i.e., food) and left (i.e., observing) keys. The right key was always dark and inoperative. For Pigeons 77 and 210, the mixed-schedule stimuli were three black vertical lines on a white background during the rich component and three black horizontal lines on a white background during the lean component. For Pigeons 79 and 123, the mixed-schedule stimuli were black lines on a white background projected at a 135° angle during the rich component and at 45° during the lean component. The mixed-schedule stimuli remained on the keys unless responses occurred to the observing key. Responses to the observing key changed the mixed schedule to a multiple schedule by producing 15-s exposure (exclusive of reinforcement time) to the multiple schedule stimuli (as described above) on the left and center keys. Observing responses produced the change from mixed schedule to multiple-schedule stimuli on an FI 0.75-s schedule. Thus observing responses within 0.75 s of the offset of the previous stimulus presentation were recorded but had no consequences. In addition, responses to the observing key during 15-s stimulus presentations had no programmed consequences. Transitions between RI schedules and extinction during a 15-s stimulus presentation were accompanied by the appropriate change in stimulus conditions. A changeover delay prevented responses on the food key from producing reinforcer deliveries within 3 s after a response to the observing key. Across baseline conditions, obtained reinforcement rates in the RI portions of the rich ($M = 3.7$ reinforcers/min) and lean ($M = 1.0$ reinforcers/min) components were similar to the programmed reinforcement rates.

These conditions remained in effect until observing rates (observing responses during mixed schedule/time in mixed schedule) and response rates on the food key appeared stable in the rich and lean components as judged visually across at least five sessions. Sessions occurred at approximately the same time each day and were generally conducted 7 days per week.

Disruption by prefeeding. Following stability, the disruptive effects of increasing amounts of home-cage prefeeding 30 min prior to a session were examined (cf. Nevin *et al.*, 1981). Pigeons were fed 5%, 10%, and 15% of their running weights, in that order. Next, the effects of either the 10% (Pigeons 77 and 79) or 15% (Pigeons 210 and 123) prefeeding were replicated. Between prefeeding amounts, the baseline was reinstated for a minimum of five sessions and until behavior had stabilized. Table 1 presents the numbers of sessions of exposure to the baseline before each prefeeding amount. The pigeons seldom ate all of the food in the 15% prefeeding conditions.

RESULTS

The left panels of Figure 1 show observing rates in the rich and lean components. Observing rates are presented for each amount of pre-session feeding and for each of the preceding 5 baseline days. In most cases, observing rates were higher in the rich component than in the lean component during both the baseline and across disrupter values. The right panels of Figure 1 show that response rates on the food key both during S+ and the mixed schedule were similar in the rich and lean components. Within each of the components, however, S+ response rates generally were higher than mixed-schedule rates. Food-key response rates during S- presentations were generally low and are shown in Table 1. Observing rates, food-key rates during S+, and food-key rates during the mixed schedule decreased little following the 5% prefeeding but decreased more consistently with the 10% and 15% prefeeding. For both observing and food-key responding, replicated prefeeding conditions sometimes produce larger and sometimes smaller decreases in response rate than did than original exposure. Nonetheless, the ordering of response rates in the rich and lean components was similar across repeated disrupters except for food-key response rates (S+ and mixed schedule) for Pigeon 79, mixed schedule response rates for Pigeon 77, and observing rates for Pigeon 123. Lean component S+ response rates for Pigeon 210 in the second 15% prefeeding and rich component S+ response rates for Pigeon 123 in the initial 15% prefeeding do not appear in the figure because no time was

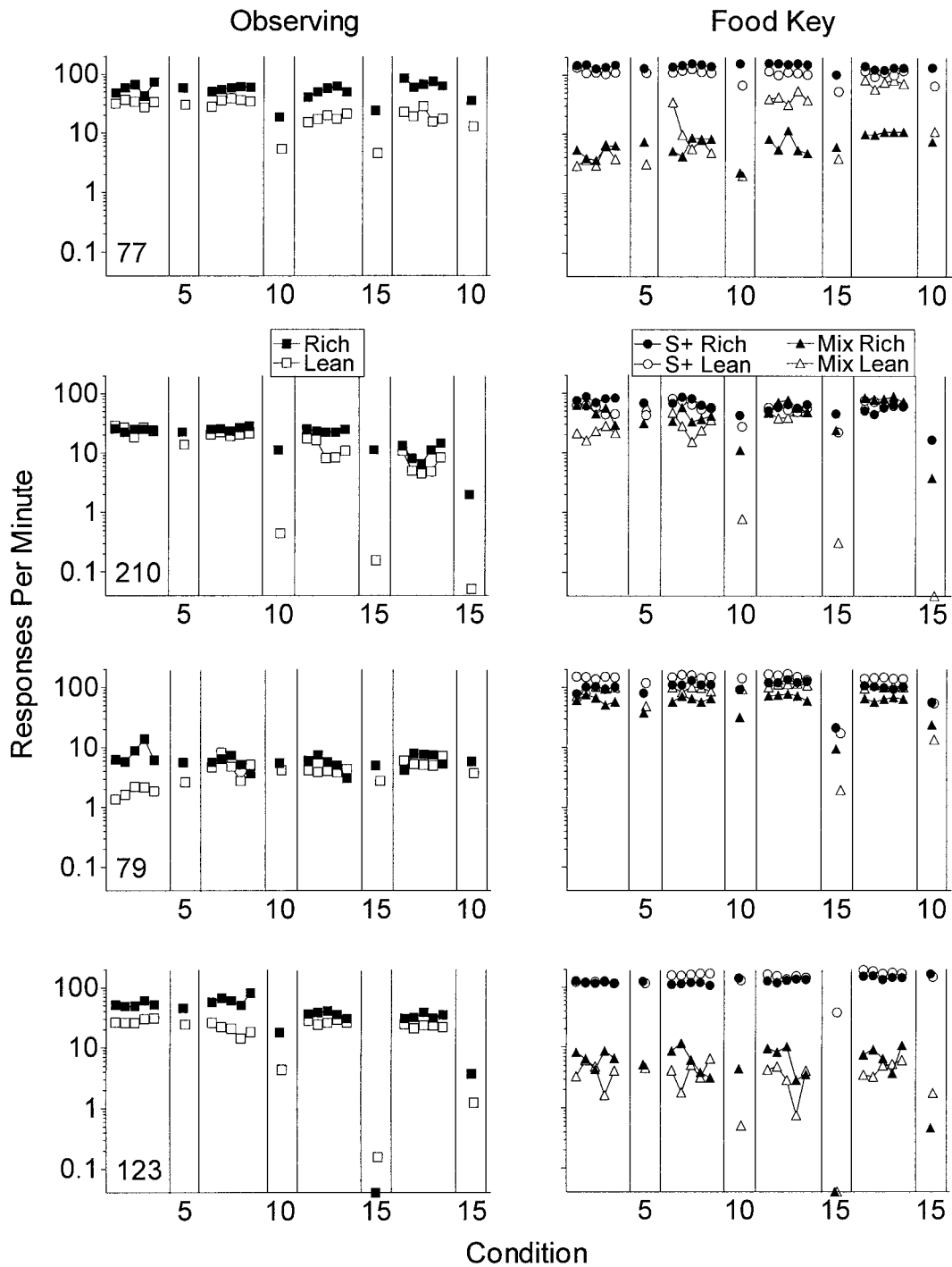


Fig. 1. The left panels show observing rates in the rich and lean components in the last five sessions of each baseline and during each session of the different pre-session feeding amounts. The right panels show response rates on the food key for the rich and lean components under the same conditions. Food-key response rates are presented separately for responding in the presence of S+ and the mixed-schedule stimulus. S- response rates are presented in Table 1. The y-axis is logarithmic. Data points located on the x-axis correspond to values of zero.

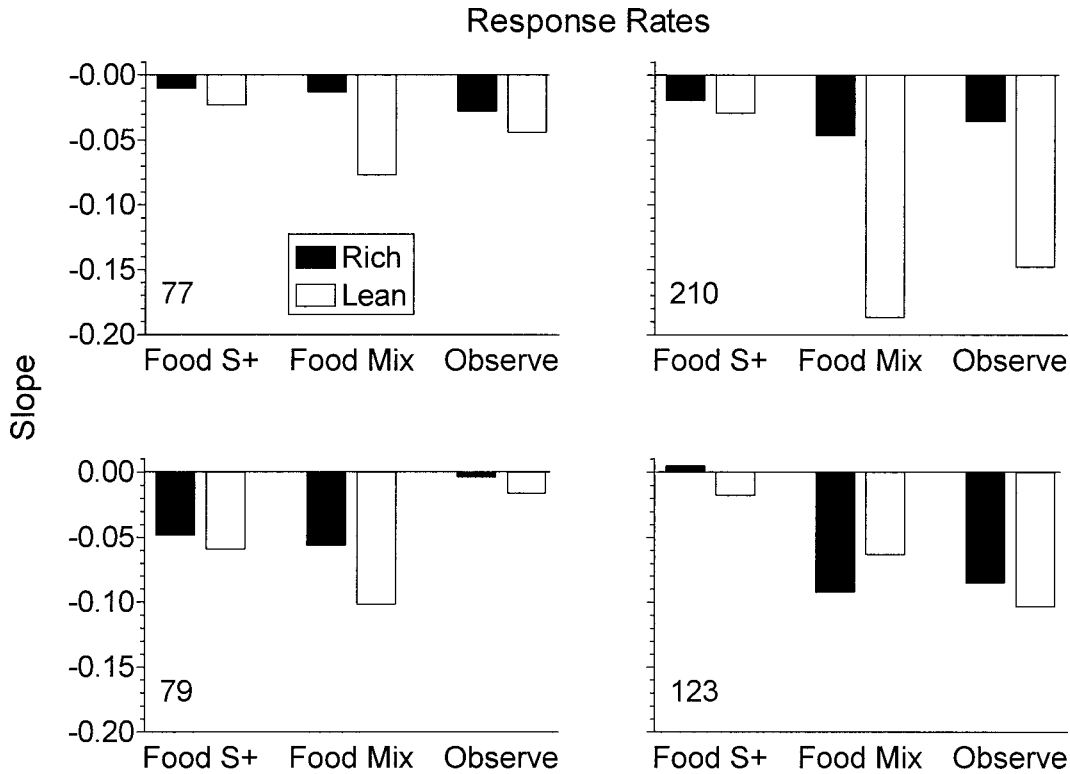


Fig. 2. Slopes of the functions relating log proportion of baseline response rates to the magnitude of the pre-session feeding amount. Slopes of functions for the rich and lean components are presented separately for food-key response rates in the presence of S+, food-key response rates in the presence of the mixed-schedule stimulus, and observing rates.

spent in the presence of S+ during these disrupters.

To examine the resistance to change of observing and food-key responding during S+ and during the mixed schedule, slopes of the functions relating log proportion of baseline response rates to the magnitude of the pre-session feeding were examined (e.g., Nevin, 1992; Nevin & Grace, 2000). Log proportion of baseline was obtained by dividing response rates during each disrupter by the mean of the immediately preceding 5 baseline days and taking the logarithm of this value. For the replicated prefeeding amount, the logarithm of the mean proportion of baseline for the two determinations was used. Linear regression was used to obtain the slopes of the resistance functions for observing rates and food-key responding during S+ and the mixed schedule. Figure 2 shows these slopes. Steeper slopes characterize responding that was less resistant to change and are repre-

sented by bars that extend to more negative values. For every pigeon, responding was less resistant to change in the lean component than in the rich component for both observing and S+ food-key responding. In addition, with the exception of Pigeon 123, responding on the food key during the mixed schedule was also more resistant to disruption during the rich component. Finally, when compared within the rich and lean components, both food-key responding during the mixed schedule and observing were less resistant to change than S+ food-key responding for Pigeons 77, 210, and 123. For Pigeon 79, observing was more resistant to change than both S+ food-key responding and food-key mixed-schedule responding.

Table 1 shows that there was a tendency for more of the available component time to be spent in the presence of S- than in the presence of S+. Given that the FI 0.75-s schedule on the observing key was functionally similar

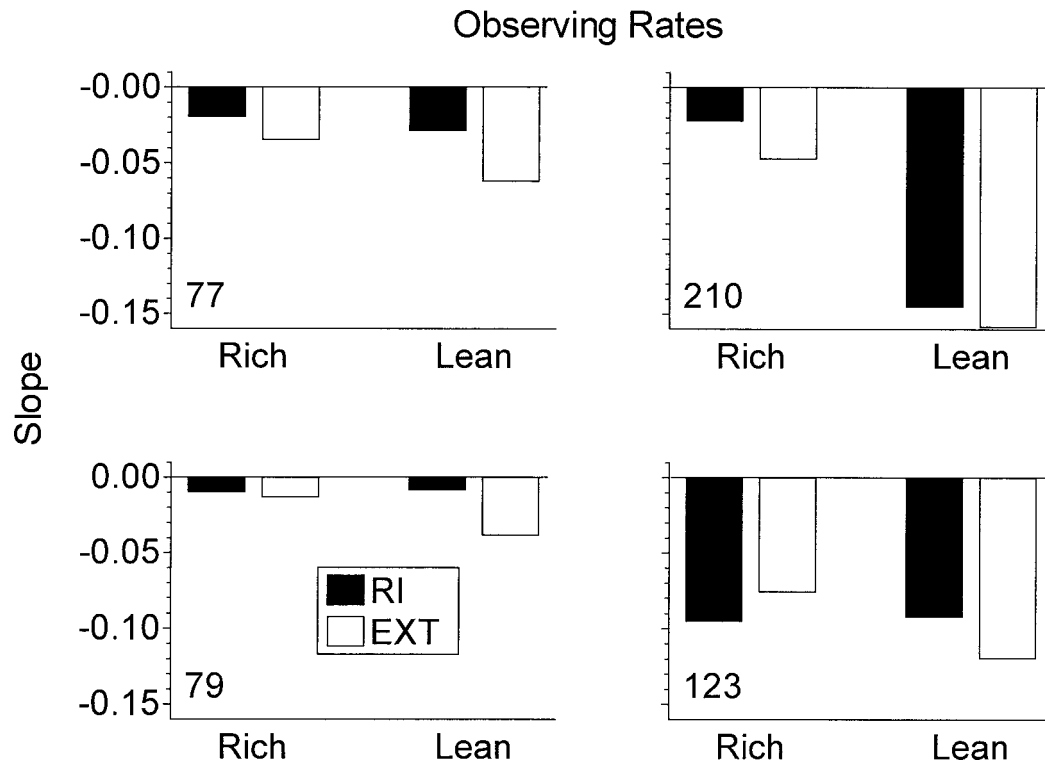


Fig. 3. Slopes of the functions relating log proportion of baseline observing rates to the magnitude of the pre-session feeding amount. Separate slopes are presented for observing during mixed-schedule RI components and mixed-schedule extinction components in both the rich and lean components.

to a fixed-ratio (FR) 1 schedule, time in the presence of S+ and S- varied with observing rates. Thus the greater percentage of available time spent in the presence of S- suggests that observing was more likely during extinction components than during RI components when the mixed schedule was in effect. Accordingly, Table 1 also shows response rates on the observing key separately for RI and extinction components during the mixed schedule for both the rich and lean components. In 28 of 32 baseline comparisons, observing rates were higher during extinction components than during the RI components. The only exceptions to this result were in all four comparisons in the rich component for Pigeon 123.

To determine if observing was differentially resistant to change in the mixed-schedule RI and extinction components, a more detailed analysis of the disruptions in observing was conducted. Figure 3 shows a resistance to change analysis conducted separately for observing rates during mixed-schedule RI and

extinction components. This analysis was conducted as described above for overall observing rates, but separate slopes were obtained for observing rates in the RI and extinction components. With the exception of Pigeon 123 in the rich component, observing during the RI components was more resistant to change than observing during extinction components. This difference was small, however, for Pigeon 79 in the rich component.

DISCUSSION

The present experiment extended the study of resistance to change to observing behavior. Observing was more resistant to change in a component in which it produced stimuli associated with a higher rate of primary reinforcement. In addition, the finding that response rates on the food key during both S+ and during the mixed schedule were more resistant to change in the rich component replicates the typical result obtained with simple multiple schedules (see Nevin, 1992; Nevin & Grace, 2000, for reviews). Sim-

ilarly, within the rich and lean components, mixed-schedule responding on the food key was less resistant to change than S+ responding on the food key. This result is also consistent with data from simple multiple schedules, given that S+ was associated with reinforcement rates that were twice as high as those arranged during the mixed schedule.

Although the present experiment showed the effects of rate of primary reinforcement on the resistance to change of observing, this experiment has some important limitations. First, data examining the resistance to change of observing were based on relatively few observations, and two determinations of one of the magnitudes of pre-session feeding produced different results for Pigeon 123. Second, observing was reinforced on an FI 0.75 schedule of reinforcement that essentially functioned as an FR 1 schedule. Thus decreases in observing produced decreases in the rate of stimulus presentations. The role of this FR 1-like schedule in the production of the present results is unknown. Generally, behavioral momentum effects are examined with longer interval schedules because with these schedules only relatively large decreases in response rates produce decreases in reinforcement rates.

EXPERIMENT 2

This experiment further examined the effects of rate of primary reinforcement on the resistance to change of observing behavior. As in Experiment 1, a multiple-schedule of observing-response procedures was arranged. In both the rich and lean components, observing was maintained on an RI 15-s schedule of reinforcement. In an effort to extend the examination of the resistance to change of observing to other disruption procedures, 5-day blocks of pre-session feedings and 5-day blocks of intercomponent interval (ICI) response-independent food deliveries were used to disrupt performance.

METHOD

Subjects and Apparatus

The subjects and apparatus were those used in Experiment 1.

Procedure

As a result of their experience in Experiment 1, the subjects required no additional training prior to the present experiment. The procedure was the same as in Experiment 1 with a few modifications. The durations of the rich and lean components were decreased to 5 min and the number of presentations of each component per session was increased to four. In addition to the 30-s intercomponent blackouts separating the rich and lean components, a 30-s pre-session blackout was introduced. In an attempt to make responding less resistant to change in both components, reinforcement rates were decreased by changing to RI 30-s and RI 120-s schedules of food delivery in the rich and lean components, respectively. Finally, observing in both components produced 15-s presentations of schedule-correlated stimuli on an RI 15-s schedule of reinforcement. The RI schedules were programmed as described for the food key in Experiment 1. Transitions between RI and extinction components had no effect on undelivered stimulus presentations arranged for pecks to the observing key, but undelivered stimulus presentations were cancelled with transitions between the rich and lean components. Other details of the procedure were the same as in Experiment 1. Reinforcement rates during the RI portions of the rich ($M = 1.9$ reinforcers/min) and lean ($M = 0.48$ reinforcers/min) components were similar to programmed reinforcement rates. Sessions occurred at approximately the same time each day and were generally conducted 7 days per week.

Following stability in observing and food-key response rates, as judged visually across at least five sessions, 5-day blocks of pre-session feeding and 5-day blocks of ICI response-independent food deliveries were used to disrupt performance. In the 5-day block of pre-session feeding, 30 min before the session the pigeons were fed 20 g, 30 g, 40 g, 40 g, and 40 g, in that order (cf. Nevin & Grace, 1999; Nevin, Tota, Torquato, & Shull, 1990). With the exception of Pigeon 123 on the final 40 g prefeeding, the pigeons always ate all of the food. After running weights were recovered and a stable baseline was reestablished, 2-s deliveries of the food hopper were presented during the pre-session and ICI black-

outs on a random time (RT) 7.5-s schedule (cf. Nevin, 1974). Table 2 shows the number of sessions in each baseline before the disrupters were introduced.

RESULTS

The left panels of Figure 4 show observing response rates for the rich and lean components. Data are shown for the last five sessions of baseline before each disrupter and for each of the five sessions for pre-session feeding and ICI food deliveries. With the exception of Pigeon 210, observing rates were higher in the rich component than in the lean component. For Pigeons 77, 210, and 123, pre-session feeding substantially decreased observing in both components. For these same pigeons, the decreases in observing produced by ICI food were more modest. Pre-session feeding and ICI food did not affect observing for Pigeon 79. The right panels of Figure 4 show that response rates on the food key during both S+ and the mixed schedule were similar for the rich and lean components. Within components, response rates were always higher during S+ than during the mixed schedule. Response rates during S- were low across components and are shown in Table 2.

Figure 5 summarizes the disruptions produced by pre-session feeding and ICI food for food-key rates during S+ and the mixed schedule and for observing rates. The data in the figure reflect the mean proportion of baseline, which was calculated by dividing response rates for each session of the disrupter by the mean of the preceding baseline and averaging these values across the five sessions of the disrupter. The top panel of Figure 5 shows that, with the exception of Pigeon 77, response rates during S+ were more resistant to the effects of pre-session feeding in the rich component than in the lean component. Similarly, with the exception of Pigeon 79, response rates on the food key during the mixed schedule and observing rates were more resistant to the disruptive effects of pre-session feeding in the rich component than in the lean component. Both observing and food-key rates during the mixed schedule were generally less resistant to pre-session feeding than response rates on the food-key during S+. The bottom panel of Figure 5 shows that response rates on the food-key

during S+ were more resistant to the disruptive effects of ICI food in the rich component than the lean component for only Pigeons 77 and 79. Response rates on the food key during the mixed schedule, however, were more resistant to the effects of ICI food in the rich component than the lean component for all 4 pigeons. Similarly, with the exception of Pigeon 79, observing rates in the rich component were more resistant to the disruptive effects of ICI food than observing rates in the lean component. Different from the effects of pre-session feeding above (see also Experiment 1), food-key rates during S+ were not reliably more resistant to the disruptive effects of ICI food than observing and food-key rates during the mixed schedule.

Response rates on the observing key were examined separately for RI and extinction components during the mixed schedule. Table 2 shows that in a majority of the comparisons during baseline, response rates on the observing key were higher during extinction than during RI. The exceptions to this result were the rich component in the pre-session feeding baseline for Pigeon 210 and all four comparisons for Pigeon 123. Despite the generally higher rates of observing during extinction components for 3 of 4 pigeons, the top panel of Figure 6 shows that observing was more resistant to the disruptive effects of pre-session feeding during RI components than during extinction components in both the rich and lean components. The bottom panel shows that the results for ICI food are less clear. In those cases in which observing increased during ICI food (Pigeons 77 and 210 during the rich component and Pigeon 79 during the lean component), the increases were larger relative to baseline in the RI components than in the extinction components. Finally, as would be expected based on Figure 5, observing for Pigeons 77, 210, and 123 in both the RI and extinction components was more resistant to pre-session feeding (top panels) and ICI food (bottom panels) in the rich component than in the lean component.

DISCUSSION

This experiment replicated and extended the results of Experiment 1 to a procedure maintaining observing on RI schedules and using different disruption procedures. As in Experiment 1, observing was more resistant

Table 2

Sessions in each baseline (BL) preceding pre-session feeding (PF) and RT 7.5 food deliveries in the ICI (RT), mean and standard deviation (in parentheses) total percentage of available time spent in the presence of schedule correlated stimuli, percentage of time spent in S+ and S-, food-key response rates during S- presentations, and observing rates during RI and extinction components during the mixed schedule for the last five sessions of each baseline and each session of the disrupter for the rich and lean components.

Subject	Condition	Sessions	Percentage of available time						
			Rich			Lean			
			Total	S+	S-	Total	S+	S-	
P77	PF BL	37	0.41 (0.03)	0.22 (0.04)	0.19 (0.04)	0.42 (0.04)	0.19 (0.04)	0.23 (0.02)	
	PF 20g	1	0.37	0.16	0.20	0.35	0.20	0.15	
	PF 30g	1	0.31	0.13	0.18	0.30	0.13	0.17	
	PF 40g	1	0.36	0.18	0.18	0.29	0.09	0.20	
	PF 40g	1	0.35	0.18	0.17	0.30	0.14	0.16	
	PF 40g	1	0.24	0.15	0.09	0.01	0.00	0.01	
	RT BL	16	0.40 (0.05)	0.19 (0.04)	0.21 (0.02)	0.41 (0.03)	0.17 (0.04)	0.24 (0.03)	
	RT 7.5s	1	0.42	0.18	0.25	0.30	0.13	0.17	
	RT 7.5s	1	0.43	0.22	0.21	0.32	0.13	0.20	
	RT 7.5s	1	0.45	0.22	0.23	0.35	0.11	0.23	
	RT 7.5s	1	0.43	0.29	0.15	0.39	0.25	0.13	
	RT 7.5s	1	0.42	0.21	0.21	0.37	0.14	0.23	
	P210	PF BL	93	0.43 (0.02)	0.22 (0.05)	0.21 (0.05)	0.45 (0.01)	0.23 (0.05)	0.22 (0.04)
		PF 20g	1	0.22	0.22	0.43	0.42	0.16	0.26
		PF 30g	1	0.20	0.22	0.42	0.38	0.19	0.19
PF 40g		1	0.23	0.20	0.44	0.29	0.15	0.14	
PF 40g		1	0.11	0.14	0.25	0.14	0.07	0.07	
PF 40g		1	0.05	0.08	0.13	0.09	0.03	0.06	
RT BL		21	0.39 (0.03)	0.20 (0.04)	0.30 (0.05)	0.42 (0.03)	0.20 (0.03)	0.21 (0.05)	
RT 7.5s		1	0.38	0.22	0.17	0.42	0.22	0.20	
RT 7.5s		1	0.43	0.19	0.24	0.46	0.23	0.23	
RT 7.5s		1	0.32	0.16	0.16	0.37	0.17	0.20	
RT 7.5s		1	0.34	0.20	0.14	0.45	0.17	0.28	
RT 7.5s		1	0.36	0.17	0.20	0.36	0.19	0.17	
P79		PF BL	67	0.40 (0.03)	0.18 (0.02)	0.22 (0.04)	0.34 (0.03)	0.16 (0.04)	0.18 (0.05)
		PF 20g	1	0.39	0.17	0.21	0.31	0.15	0.16
		PF 30g	1	0.37	0.19	0.18	0.35	0.16	0.19
	PF 40g	1	0.33	0.18	0.15	0.32	0.18	0.14	
	PF 40g	1	0.35	0.12	0.23	0.39	0.23	0.15	
	PF 40g	1	0.38	0.20	0.18	0.30	0.16	0.14	
	RT BL	28	0.36 (0.04)	0.17 (0.03)	0.19 (0.02)	0.31 (0.03)	0.15 (0.02)	0.15 (0.04)	
	RT 7.5s	1	0.29	0.16	0.13	0.26	0.14	0.13	
	RT 7.5s	1	0.34	0.16	0.2	0.28	0.11	0.17	
	RT 7.5s	1	0.34	0.14	0.20	0.29	0.09	0.20	
	RT 7.5s	1	0.32	0.14	0.18	0.36	0.16	0.21	
	RT 7.5s	1	0.31	0.15	0.16	0.28	0.19	0.09	
	P123	PF BL		0.49 (0.06)	0.28 (0.03)	0.21 (0.07)	0.48 (0.03)	0.25 (0.04)	0.22 (0.02)
		PF 20g	1	0.20	0.27	0.47	0.50	0.27	0.23
		PF 30g	1	0.21	0.25	0.46	0.34	0.18	0.17
PF 40g		1	0.09	0.14	0.24	0.05	0.02	0.02	
PF 40g		1	0.22	0.05	0.26	0.08	0.05	0.03	
PF 40g		1	0.11	0.11	0.22	0.24	0.11	0.13	
RT BL		37	0.46 (0.02)	0.27 (0.07)	0.19 (0.07)	0.49 (0.03)	0.25 (0.04)	0.24 (0.06)	
RT 7.5s		1	0.45	0.22	0.23	0.43	0.21	0.22	
RT 7.5s		1	0.47	0.26	0.21	0.46	0.19	0.27	
RT 7.5s		1	0.56	0.28	0.28	0.47	0.26	0.21	
RT 7.5s		1	0.49	0.31	0.18	0.47	0.22	0.25	
RT 7.5s		1	0.55	0.22	0.34	0.43	0.22	0.21	

Table 2
(Extended)

S-food-key responses per minute		Observing rates mixed			
		Rich		Lean	
Rich	Lean	RI	Extinction	RI	Extinction
0.76	0.45	16.30	35.54	11.23	16.42
(0.37)	(0.76)	(3.60)	(8.35)	(1.53)	(2.75)
0.49	0.00	8.87	21.27	4.99	6.28
1.14	0.30	15.12	19.53	3.40	5.01
0.56	0.00	6.82	13.63	4.71	8.95
1.16	0.00	9.19	10.03	6.62	2.57
0.00	0.00	3.88	3.56	0.00	0.11
1.83	0.41	15.06	31.51	12.23	19.95
(0.96)	(0.15)	(3.47)	(10.61)	(6.14)	(6.32)
0.20	0.00	10.22	16.74	3.51	10.01
0.47	0.00	17.84	39.28	5.15	8.92
0.21	0.21	14.46	40.61	6.36	6.40
0.00	0.37	24.78	24.00	10.50	7.47
0.95	0.00	17.40	37.18	17.31	14.43
0.11	0.09	14.96	13.66	29.86	31.61
(0.15)	(0.12)	(2.36)	(3.95)	(4.78)	(5.48)
0.00	0.19	13.36	11.27	26.20	15.65
0.00	0.00	20.48	19.67	12.21	13.19
0.00	0.00	16.75	13.75	8.83	8.91
0.36	0.00	5.14	1.72	2.81	1.89
0.00	0.00	0.80	1.00	0.40	1.59
0.04	0.11	9.42	11.84	27.54	31.29
(0.10)	(0.26)	(2.82)	(4.83)	(5.56)	(3.34)
0.00	0.00	14.21	13.33	12.43	22.56
0.42	0.00	11.82	12.54	31.88	41.46
0.00	0.25	8.33	17.57	23.63	20.60
0.35	0.35	10.98	10.22	30.68	24.10
0.00	0.00	10.95	12.45	21.61	21.64
0.08	0.56	10.22	18.65	5.91	10.62
(0.12)	(0.63)	(4.24)	(2.26)	(2.37)	(4.87)
0.23	0.62	18.33	16.98	4.59	7.12
0.27	0.52	8.27	11.61	7.39	8.19
0.00	0.00	7.87	9.88	5.86	6.85
0.00	0.00	4.17	12.30	9.96	6.11
0.00	0.00	8.60	10.58	6.50	4.06
0.17	0.38	8.19	8.928	5.05	7.28
(0.15)	(0.55)	(3.09)	(4.18)	(2.32)	(1.36)
0.00	1.20	5.62	5.08	2.51	9.01
0.00	0.29	12.73	7.92	8.15	7.17
0.00	0.25	10.01	12.53	9.21	9.21
0.28	0.24	7.53	8.87	11.06	11.40
0.00	0.00	2.83	6.75	6.59	4.12
0.29	0.51	109.02	80.05	79.26	59.4
(0.27)	(0.32)	(5.87)	(5.71)	(15.27)	(12.1)
0.19	0.43	96.92	60.58	52.25	44.51
0.99	0.30	75.56	52.08	39.16	23.45
3.45	2.00	25.89	14.26	0.20	1.36
0.00	11.07	21.84	15.15	1.42	0.60
10.92	10.73	18.38	10.69	16.08	3.37
0.86	0.59	138.01	100.66	96.55	69.61
(0.61)	(0.33)	(4.10)	(6.12)	(24.19)	(4.22)
0.88	0.22	108.9	51.59	58.98	32.33
0.93	0.00	111.5	75.22	49.58	29.73
0.54	0.24	127.4	39.85	43.51	29.49
0.28	0.00	109.5	62.26	38.67	28.16
0.45	0.00	125.2	73.98	46.12	38.97

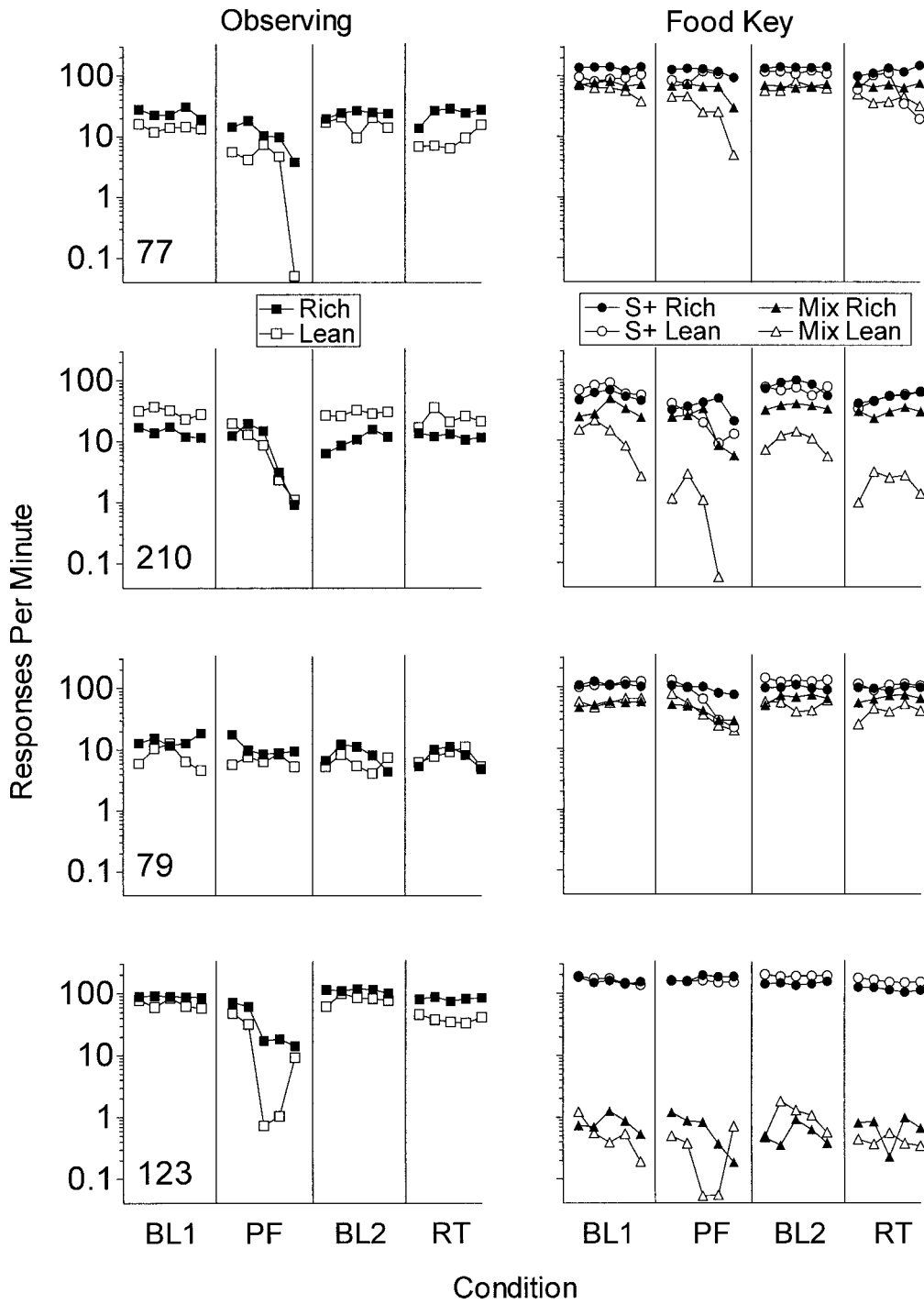


Fig. 4. The left panels show observing rates in the rich and lean components in the last five sessions of each baseline and during the five sessions of precession feeding and intercomponent RT food. The right panels show response rates on the food key for the rich and lean components for under same conditions. Food-key response rates are presented separately for responding in the presence of S+ and in the presence of the mixed-schedule stimulus. S- response rates are presented in Table 2. The y-axis is logarithmic.

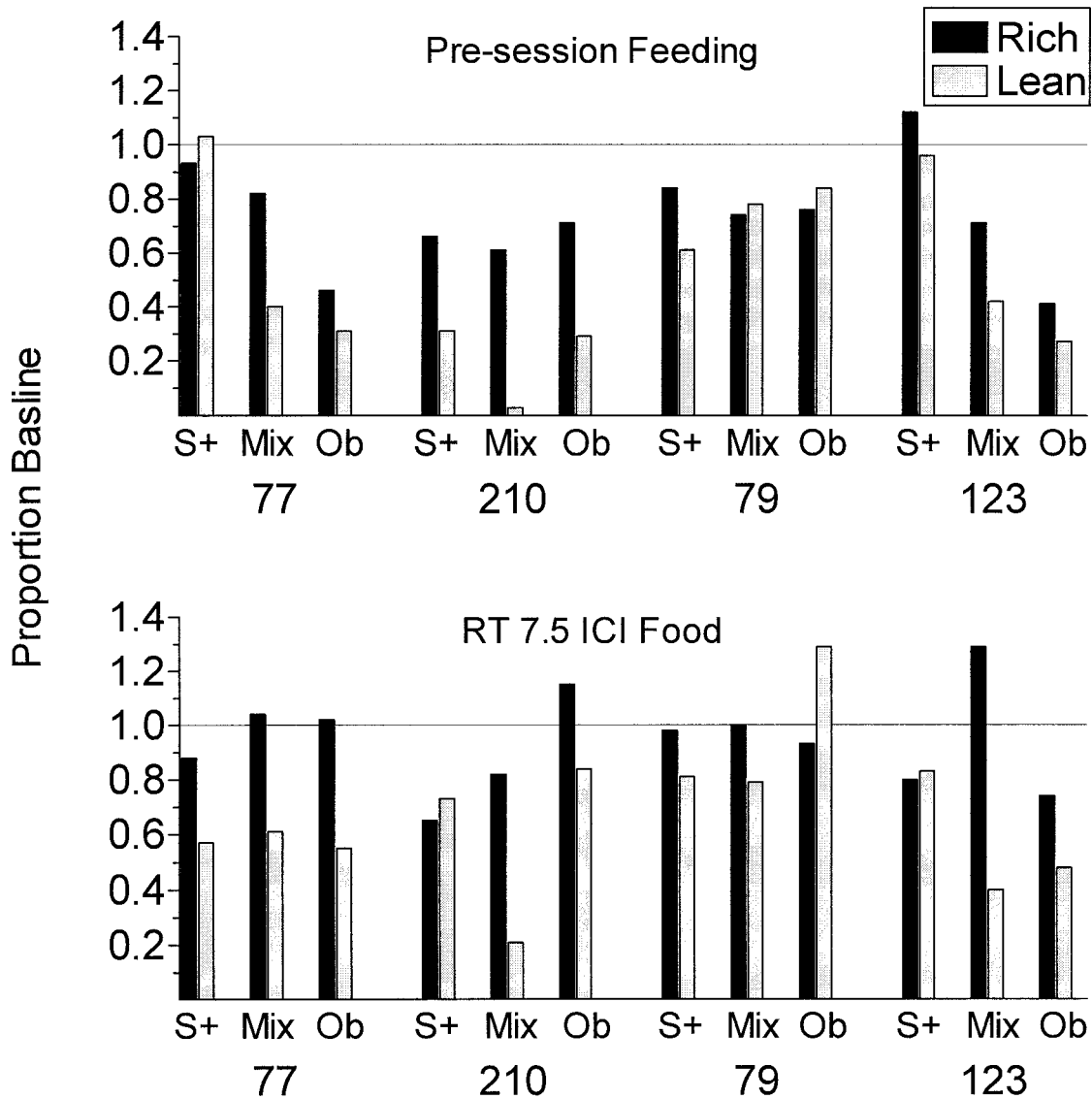


Fig. 5. The top panel shows the mean proportion of baseline for food-key responding in the presence of S+, food-key responding in the presence of the mixed-schedule stimulus, and observing rates in the rich and lean components during the five sessions of pre-session feeding. The bottom panel shows the same measures during the five sessions of intercomponent RT food deliveries.

to change in a component in which it produced contact with a stimulus associated with a higher rate of primary reinforcement. In addition, although observing occurred at a lower rate during RI than during extinction components, observing was more persistent during RI components when it was likely to produce contact with S+. Finally, also as in Experiment 1, observing and food-key responding during the mixed schedule were

more resistant to the change in the rich component than in the lean component. On average, food-key responding during S+ was more resistant to the disruptive effects of both disrupters in the rich component than in the lean component, but this difference was evident for only 2 of 4 pigeons in the ICI food condition. In addition, the disruptions produced by ICI food were often smaller for food-key responding during the mixed sched-

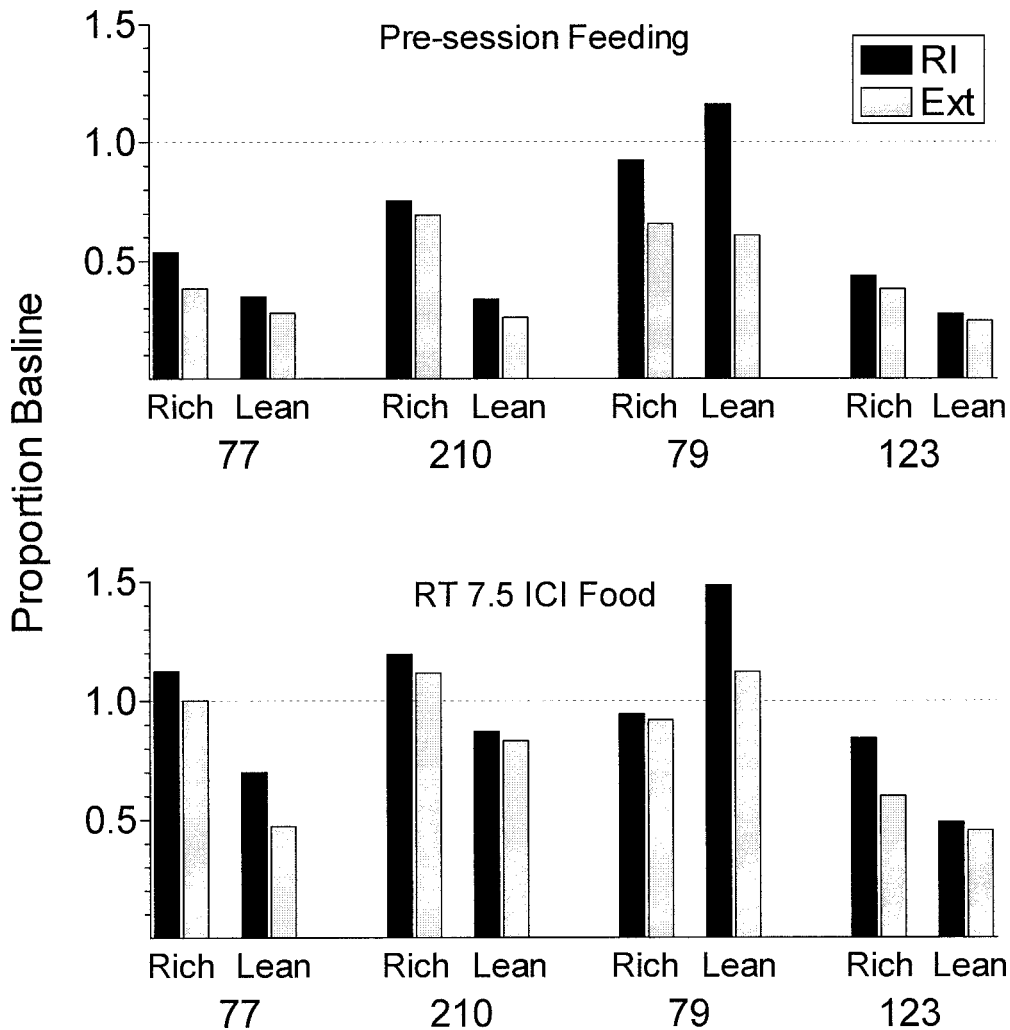


Fig. 6. The top panel shows the mean proportion of baseline observing rates for the five sessions of pre-session feeding in the rich and lean components during mixed-schedule RI and extinction components for each pigeon. The bottom panel shows the same measures during the five sessions of intercomponent RT food deliveries.

ule and observing than those produced by pre-session feeding, despite the fact that the rate of ICI food used in the present experiment was higher (480 foods/hr) than in many previous studies of resistance to change (e.g., Nevin, 1974; Nevin *et al.*, 1983; Nevin, Milo, Odum, & Shahan, 2003). Nevin, Grace, Holland, and McLean (2001), however, failed to obtain consistent disruptions in responding with up to 432 ICI food deliveries per hour. The reasons for these sometimes inconsistent effects of ICI food deliveries are presently unknown. Regardless, the disruptions in observing and food-key responding during

the mixed schedule were typically larger in the lean component than in the rich component.

GENERAL DISCUSSION

Observing occurred at a higher rate (cf. Shahan, 2002) and was more resistant to change in a component in which it was maintained by the production of a stimulus associated with a higher rate of primary reinforcement. In addition, responding on the food key was generally more resistant to change in the presence of stimuli associated with higher

reinforcement rates. This differential resistance to change of food-key responding was obtained both when responding was compared across the rich and lean components and when S+ and mixed-schedule responding were compared within the rich and lean components. These effects of differential reinforcement rates on resistance to change replicate the typical result obtained with simple multiple schedules (see Nevin, 1992; Nevin & Grace, 2000) and extend it to a situation in which the subject controls the duration of exposure to the stimulus conditions signaling differential reinforcement rates.

The finding that both the rate and persistence of observing depended on the rate of primary reinforcement is consistent with the effects of terminal-link reinforcement rate on the rate and persistence of initial-link responding in multiple chain schedules (Nevin et al., 1981). The similarity of the present results to those of Nevin et al. suggests that the dependency between initial-link completion and access to the terminal link was not responsible for their results. The higher rates of observing in the rich component are also consistent with the effects of terminal-link reinforcement rates on preference in the initial links of concurrent-chains schedules (e.g., Herrnstein, 1964; for review see Williams, 1988). In addition to these effects on preference, the present findings and those of Nevin et al. show that relatively better stimulus-reinforcer relations also increase the persistence of behavior that produces contact with them. These findings are consistent with the suggestion that preference, value, resistance to change, and response strength are reflections of a single central construct (Grace & Nevin, 1997; Nevin, 1974; Nevin & Grace, 2000).

Despite the fact that in the observing-response procedure only S+ signals an improved stimulus reinforcer relation, observing necessarily produces both S+ and S-. Nevertheless, extensive previous research has shown that observing is maintained only by S+ presentations (e.g., Dinsmoor, Browne, Lawrence, 1972; Mulvaney, Dinsmoor, Jwaid, & Hughes, 1974; see Dinsmoor, 1983; Fantino, 1977, for reviews). As is often the case with fixed-duration observing-stimulus durations, more of the available time was spent in the presence of S- than S+ when

these percentages varied closely with observing rates in Experiment 1. Similarly, in both experiments, observing rates were generally higher during unsignaled extinction components than during unsignaled RI components. Competition between the primary and conditioned reinforcers is often cited as the source of such effects (e.g., Kelleher, Riddle, & Cook, 1962; Shahan, 2002; see also Dinsmoor, 1983). Regardless, observing rates during RI components were more resistant to change than observing rates during extinction components. For this outcome to occur, the alternating RI and extinction components during the mixed schedule must have been discriminated to some extent. This discrimination was likely based on recent stimulus presentations (S+ or S-) and/or food presentations. Thus it appears that relatively local modulations in the persistence of observing may occur depending on what stimulus an observing response is likely to produce at a given time. This differential persistence of observing when it is likely to produce S+ suggests that resistance to change provides a measure of the reinforcing value of S+ that is impacted less by competition between the primary and conditioned reinforcers than by observing rates or percentage of time spent in S+.

The resistance to change of observing behavior was of particular interest here because observing has been considered an analog of attending and appears to play an important role in the development and maintenance of stimulus control (Dinsmoor, 1985). Given the apparent role of observing in stimulus control, the present results may be relevant for interpreting data from recent experiments examining the resistance to change of discrimination performance (Dube & McIlvane, 2002; Nevin et al., 2003). Nevin et al. examined conditional discrimination performance in a multiple schedule of reinforcement. One component of the multiple schedule reinforced accurate discrimination with a greater probability than the other component. Consistent with previous findings on the emission of simple operant behavior, accuracy of the conditional discrimination was more resistant to various disrupters in the component with higher reinforcement probability. One interpretation of these findings is that the decreases in conditional discrimination accuracy re-

sulted from disruptions in attending to the sample stimuli. The greater resistance to change of the conditional discrimination in the higher reinforcement probability component could have resulted from more persistent attending to the sample in that component. The finding in the present experiments that the persistence of observing behavior was sensitive to differential rates of primary reinforcement suggests that the disrupters used by Nevin *et al.* may have produced larger disruptions in attending to the sample in the lean component.

Although the present experiments demonstrated that the resistance to change of observing behavior was sensitive to differential rates of primary reinforcement, they did not assess differential sensitivity quantitatively. Such a quantitative assessment would be especially important for determining if the persistence of observing is as sensitive to relative reinforcement rates as responding maintained directly by a primary reinforcer. The most appropriate way to quantify such sensitivity is to vary the ratio of reinforcement rates in the two components and examine resultant changes in relative resistance to change (Nevin, 1992). In the absence of a direct assessment, Nevin, McLean, and Grace (2001) noted that sensitivity can be estimated for a given pair of multiple schedule components with a fixed reinforcement ratio by examining the relation between the disruptions in responding in those components across a series of disrupters. Specifically, sensitivity is obtained by examining the relation between the log proportion of baseline in one component and the log proportion of baseline in the other component. Assuming that the same disrupter is applied equally to both components, the equation for this relation is:

$$\begin{aligned} &\log(Bx_1/B_0_1) \\ &= (r_2/r_1)^a[\log(Bx_2/B_0_2)], \end{aligned} \quad (1)$$

where $\log(Bx_1/B_0_1)$ and $\log(Bx_2/B_0_2)$ are the log proportions of baseline in rich and lean components, respectively, r_2/r_1 is the ratio of lean to rich reinforcement rates, and a is an index of sensitivity to relative reinforcement rate. Given that the ratio of lean to rich reinforcement rates in the two components of the present experiments was 0.25, a can be

obtained from the slope [i.e., $(r_2/r_1)^a$] of the relation.

Sensitivity of the persistence of observing and food-key responding to relative reinforcement rate was estimated by examining the relation between log proportion of baseline in the rich and lean components averaged across pigeons for the disruption conditions of Experiments 1 and 2. Figure 7 shows separate relations for observing, food-key responding during S+, and food-key responding during the mixed schedule. Because these relations are between two dependent variables, it is technically appropriate to estimate their parameters with structural linear relations (Isaac, 1970). Nonetheless, estimates of parameters derived from structural relations and standard linear regression for these data were always within rounding error. Thus standard linear regression was used for ease of further analysis and presentation. The slopes (0.48, 0.58, and 0.48) and intercepts (0.01, 0.01, and 0.04) of the three relations are similar for observing, S+ food-key responding, and mixed-schedule food-key responding, respectively. The fact that all of the slopes are less than 1 reflects the finding that responding was more resistant to change in the rich than in the lean component. The slopes and intercepts of the relations were compared using analysis of covariance procedures performed with the "compare slopes and intercepts" function of GraphPad Prism (version 3.00 for Windows, GraphPad Software, San Diego, California USA). Neither the slopes $F(2, 12) = 0.11$, $p = 0.90$, nor the intercepts $F(2, 14) = 0.59$, $p = .57$ of the relations differed significantly. Thus observing and food-key responding under the two stimulus conditions appear to be similarly sensitive to relative reinforcement rates and can be described by a single relation with a slope of 0.47 and an intercept of 0.01. With $r_2/r_1 = 0.25$ and $(r_2/r_1)^a = 0.47$, the resultant value of a (i.e., sensitivity) is 0.54, a value similar to previous estimates (e.g., Nevin, McLean, & Grace, 2001) for food-maintained responding in multiple schedules. Two notes of caution about this conclusion are in order. First, because S+ responding was less disrupted (evident in Figure 7 by its less extreme extension to lower x -axis values) than mixed-schedule responding and observing, the slope parameter for

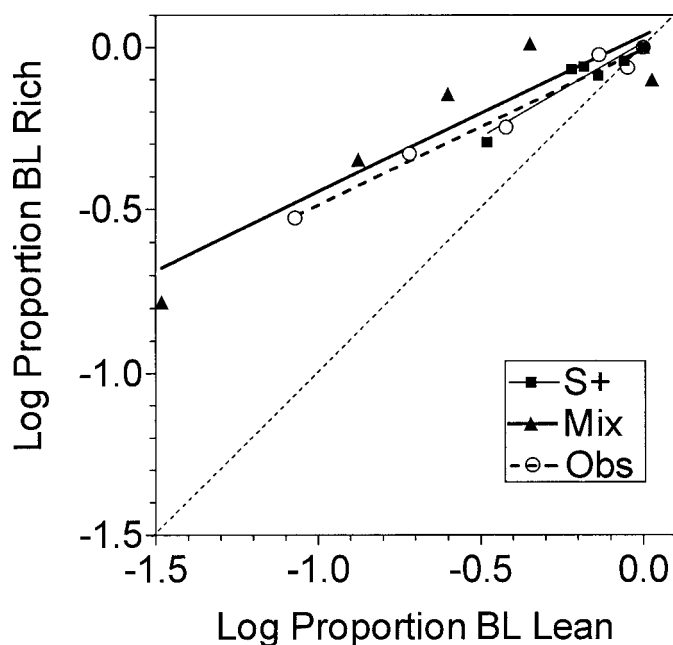


Fig. 7. Mean log proportion of baseline in the rich component during the disruption conditions of Experiments 1 and 2 plotted as a function of mean log proportion of baseline in the lean component in the same conditions. Separate relations are plotted for observing, food-key responding during S+, and food-key responding during the mixed schedule. Least squares linear regression lines were fitted to the data average across pigeons.

that relation was derived from a relatively restricted range. Data from conditions that produce relatively larger disruptions in S+ responding could result in different conclusions. Second, a full examination of a range of different reinforcement ratios could produce a different estimation of sensitivity from that obtained here. Nonetheless, at present, observing and food-maintained behavior appear to be similarly sensitive to relative reinforcement rates. To the extent that observing is functionally similar to attending, quantitative descriptions of resistance to change derived with simple food-maintained responding in multiple schedules appear to be applicable to attending with little modification.

Finally, the present results may have implications for problems in applied settings. For example, Dube and McIlvane (1997) have noted the potential role of inappropriate and differentially persistent observing behavior in the production of restricted stimulus control (i.e., stimulus overselectivity) in individuals with intellectual disabilities. Further analyses of the variables affecting the persistence of observing may aid in efforts to decrease the

persistence of inappropriate observing. As a second example, attentional biases to drug-related stimuli have been noted with abusers of various substances (e.g., Ehrman et al., 2002; Johnsen, Laberg, Cox, Vaksdal, & Hugdahl, 1994; Lubman, Peters, Mogg, Bradley, & Deakin, 2000; Townshend & Duka 2001). Contact with such stimuli also increases self-reports of drug craving in humans (see Carter & Tiffany, 1999, for review) and increases the likelihood (see de Wit, 1996, for review) and persistence (Shahan, 2003) of drug self-administration of nonhumans. Perhaps the results of the present experiments and similar experiments with drug reinforcers can suggest ways to decrease the persistence of such attentional biases and their resultant effects on drug taking.

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