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EFFECTS OF RESPONSE REQUIREMENT AND ALCOHOL ON HUMAN AGGRESSIVE RESPONDING

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Nine men participated in two experiments to determine the effects of increased response requirement and alcohol administration on free-operant aggressive responding. Two response buttons (A and B) were available. Pressing Button A was maintained by a fixed-ratio 100 schedule of point presentation. Subjects were instructed that completion of each fixed-ratio 10 on Button B resulted in the subtraction of a point from a fictitious second subject. Button B presses were defined as aggressive because they ostensibly resulted in the presentation of an aversive stimulus to another person. Aggressive responses were engendered by a random-time schedule of point loss and were maintained by initiation of intervals free of point loss. Instructions attributed these point losses to Button B presses of the fictitious other subject. In Experiment 1, increasing the ratio requirement on Button B decreased the number of ratios completed in 4 of 5 subjects. In Experiment 2, the effects of placebo and three alcohol doses (0.125, 0.25, and 0.375 g/kg) were determined when Button B presses were maintained at ratio values of 20, 40 and 80. Three subjects who reduced aggressive responding with increasing fixed-ratio values reduced aggressive responding further at higher alcohol doses. One subject who did not reduce aggressive responding with increasing fixed-ratio values increased aggressive responding at the highest alcohol dose. The results of this study support suggestions that alcohol alters aggressive behavior by reducing the control of competing contingencies.

Key words: aggression, alcohol, fixed-ratio schedules, response cost, button press, humans

Under experimental conditions, certain environmental stimuli (e.g., presentation of electric shock or intermittent food presentation) engender aggressive and/or escape responses. Whether aggressive responses will be more likely than escape responses will depend upon target availability, the presence of avoidance or escape history, and other factors. Aggressive responding will be generated by these environmental stimuli, and access to a target will serve as a reinforcer. The presentation of target animals or inanimate objects that are subsequently attacked will maintain responding in mice (Van Hemel, 1972), pigeons (Cherek, Thompson, & Heistad, 1973), and squirrel monkeys (Azrin, Hutchinson, & McLaughlin, 1965).

Although these studies have relied on topographic definitions of aggressive responding, research on human aggressive responding typically has followed the lead of Buss (1961) and operationally defined an aggressive response as one that delivers a noxious or aversive stimulus to another person. The reaction-time competition (Taylor, 1967) and the free-operant (Cherek, 1981) laboratory preparations have been most frequently used in studies of drug effects on human aggressive responding. In the reaction-time procedure, subjects ostensibly can deliver electric shock at intensities set before a competitive trial to a fictitious competitor. The free-operant procedure provides two response options. Responding on one alternative is maintained by presentation of points exchangeable for money. Occasionally a point is subtracted from the subject's accumulated earnings. This point loss is attributed to another person. Following point loss and completion of the response requirement for earning a point, responding on the second alternative ostensibly subtracts a point from the other subject and delays the next scheduled point loss. In these preparations, aggressive responding (a) is engendered by actual or ostensible presentation of an aversive stimulus, either shock or point loss, by another person, and (b) is maintained by escape from presentation of aversive stimuli by a fictitious person (Cherek, Spiga, Steinberg, & Kelly, 1990;

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Dengerink & Covey, 1983). The results suggest that these laboratory studies of human aggressive responding measure instrumental, emitted aggressive responding rather than hostile, elicited aggressive responding. In addition, they suggest that harm alone does not maintain aggressive responding. Rather, the transition to situations in which presentation of aversive stimuli produced by another person is decreased is the critical consequence maintaining aggressive responding; harm to the other functions as a conditioned reinforcer.

Recent studies have demonstrated that these social aggressive responses are functionally distinct from nonsocial escape responses maintained by the same consequence. Cherek and colleagues (Cherek, Steinberg, Kelly, Robinson, & Spiga, 1990), for example, found that diazepam had little or no effect on responding that enabled escape from point loss in a nonsocial context, but decreased aggressive responding that allowed escape from point loss attributed to another person in a social context. Such aggressive responses were maintained by temporary reductions in point losses initiated by the other person (i.e., aggressive responding directed at the subject).

Experiments involving three different procedures have observed increases in the frequency or intensity of aggressive responding following alcohol administration (Bennett, Buss, & Carpenter, 1969; Cherek, Steinberg, & Manno, 1985; Shuntich & Taylor, 1972). When data were collected in a manner that allowed determination of the effects of alcohol on individual subjects, it was apparent that not all subjects increased aggressive responding following alcohol administration (Cherek & Steinberg, 1987a, 1987b). In the face of data varying across subjects, it becomes important to elucidate the conditions under which alcohol effects on aggressive responding are modulated by environmental factors (i.e., behavioral mechanisms of action).

One possible mechanism is that (a) harm to the other and (b) escape from aversive stimuli produced by other persons differ in reinforcing effects across individuals in accord with their preexperimental reinforcement history. One method for assessing relative reinforcing effects is by increasing the response requirement leading to presentation of the reinforcer. For example, the number of responses emitted on a progressive-ratio schedule has been shown to vary as a function of reinforcer magnitude and deprivation (Hodos, 1961). Similar reinforcement schedules have been used to assess the relative reinforcing effects of drugs and different drug doses (Griffiths, Bigelow, & Henningfield, 1980; Griffiths, Findley, Brady, Dolan-Gutcher, & Robinson, 1975; Meisch & Lemaire, 1988, 1989). For example, Goldberg and his colleagues demonstrated that cocaine-maintained self-administration did not decrease when ratio requirement for the drug was increased, but pentobarbital-maintained self-administration decreased as response requirement was increased (Goldberg, Hoffmeister, Schlichting, & Wuttke, 1971).

The present study determined the effects of increases in response requirement on aggressive responding that ostensibly subtracted points from a fictitious subject (Experiment 1) and the effects of three different alcohol doses on aggressive responding at three different ratio requirements (Experiment 2). This allowed a determination of how increasing response requirements associated with aggressive responding might alter the effects of alcohol.

EXPERIMENT 1

In the free-operant methodology (Cherek, 1981), frequency of aggressive responding is generally directly related to the frequency of provocation (Cherek, Spiga, Bennett, & Grabowski, 1991; Cherek, Spiga, Steinberg, & Kelly, 1990). Increasing the response requirement to earn points from FR 50 to FR 500 increased the number of aggressive responses following provocation (Kelly, Cherek, & Steinberg, 1989). The first experiment sought to determine the effects of increasing the response requirement on the aggressive response.

METHOD

Subjects

Five males between the ages of 21 and 36 participated after informed consent was obtained. Subject S-485 had an experimental history involving matching-to-sample performance.

Apparatus

A response console (HT-603, BRS/LVE) containing two push buttons, stimulus lights, and an add/subtract counter (ASR-601, BRS/LVE) was located in a sound-attenuating chamber (1.2 m by 1.8 m) equipped with an overhead light and air conditioner. Continuous operation of the air conditioner fan motor provided masking noise. A Rockwell AIM-65 computer, located outside of the chamber, controlled experimental events and collected data.

Procedure

Potential subjects were recruited by advertisements placed in the classified employment section of local newspapers. Subjects were excluded if any medical illness or psychiatric disorder, including substance abuse, was detected during screening exams. Physical exams were performed by a physician's assistant, and psychiatric exams were conducted by a board-certified psychiatrist. Psychiatric screening consisted of a mental status exam and the Schedule for Affective Disorders and Schizophrenia—Lifetime Version, a standardized psychiatric interview (Spitzer & Endicott, 1978).

Extraneous drug usage was monitored by collecting urine and expired air samples daily at 8:00 a.m. on arrival in the laboratory. A complete drug screen analysis was performed on selected urine samples. This analysis was capable of detecting the presence of illicit and therapeutic compounds or their metabolites. Subjects were dismissed if any drug was detected in their urine samples. Recent alcohol intake was monitored by collecting an expired air sample using an Intoximeter Model 3000-III. If the subject's expired air sample contained alcohol, the scheduled sessions were canceled and the subject received no payment. If alcohol was detected again, the subject was removed from the study.

Subjects were read the following instructions prior to the first session:

> During each day you will be able to earn money by working at a response console. This is a drawing of the response console. As the drawing illustrates, the response console contains two buttons labeled A and B, two stimulus lights labeled A and B, and a digital counter with a green light above it and a red light below it. The lights will illuminate or light up when you press the corresponding button. For example, when you press Button A the A light comes on, and when you press Button B the B light comes on. When the A light is on, the B button does not work, and when the B light is on the A button does not work. You can only switch from one button to another when both the lights are off.
>
> Your console is linked to one of several other consoles during each session. Other individuals just like yourself will be seated at the same kind of consoles. These consoles are located at another facility.
>
> When the session starts the lights will be off and the digital counter will be at zero. If you press Button A, the A light will come on. Pressing the A button until A light goes off will add one point to the counter. Every point is worth 10 cents. As your counter advances, the green light just above the counter will flash briefly. When the green light goes off, you can press either Button A or B.
>
> During the session you might notice that the red light below the counter flashed briefly and that one point was subtracted from your counter. This means that one of the other persons subtracted a point by pushing Button B on his console. The one point that this person subtracted from your counter will be added to his counter.
>
> If you press Button B on your console, the B light will come on. Pressing Button B until the B light goes off will subtract one point from the counter of the person who is connected to your console. When the B light goes off, you can press either A or B. If you subtract a point it will not be added to your counter. Remember points the other person subtracts from you are added to his counter.

Additional instructions were presented concerning potential earnings, urine testing, and psychiatric exams.

The schedules of point addition and point subtraction and the consequences of aggressive responding have been described in detail previously (Cherek, Spiga, Steinberg, & Kelly, 1990). During sesions, the two response buttons were available as nonreversible options. Pressing Button A was maintained by a fixed-ratio (FR) 100 schedule of point presentation. Only button presses separated by at least 0.17 s counted toward completion of the ratio (Cherek, Spiga, Steinberg, & Kelly, 1990). Completion of an FR 10, 20, 40, or 80 on Button B turned the B light off and ostensibly subtracted a point from the fictitious other person. This responding was defined as aggressive, because it appeared to result in the delivery of an aversive stimulus to another person. Following the subtraction of at least one point

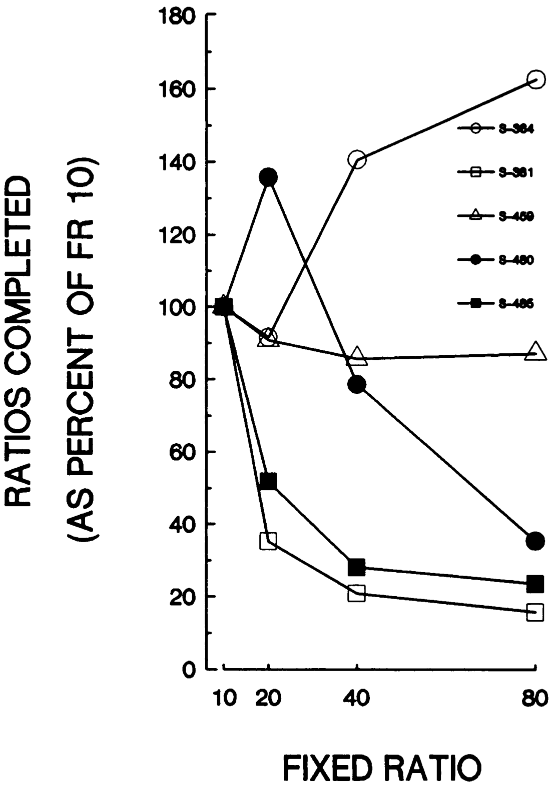

Fig. 1. The mean number of aggressive response ratios completed as a function of ratio requirement. The mean values for each subject represent the mean of the last six sessions at that FR value. The mean values are expressed as a percentage of the number of ratios completed at FR 10.

from the subject, the first response on Button B initiated a provocation-free interval (PFI) of 125 s. During the PFI, no further points were subtracted from the subject. At the end of the PFI, at least one additional point had to be subtracted from the subject before a Button B response could initiate another PFI. The PFI was initiated by the first response following a subtraction to avoid the increasing probability of point subtraction during B responding as ratio requirements increased. In the absence of Button B responses, up to 25 point subtractions were presented throughout a session, with scheduled intervals between successive point subtractions ranging from 6 to 120 s.

Each subject was exposed to a sequence of increasing FR value on Button B from FR 10, 20, 40, to 80. Some subjects had sequences of FR 10-20-10-40-10-80; other subjects had sequences of FR 10-20-40-80. Ratio values for Button B were changed after aggressive responses stabilized. The stability criterion was met if the standard deviation for the mean number of aggressive responses over six consecutive sessions was ≤15% of that mean value.

Subjects participated in either three or six sessions per day, Monday through Friday. Subjects participating in six sessions per day were given lunch at noon. Sessions were conducted at 9:00, 10:00, and 11:00 a.m. and 1:00, 2:00, and 3:00 p.m., and lasted 25 min each.

Subjects were given a questionnaire at the end of the day that asked them (a) to estimate the number of subjects they had been paired with that day, (b) to describe these other subjects, and (c) to estimate whether they or the other subjects subtracted more points.

RESULTS

All subjects reported that they had been paired with at least one other person during each day. Most of the time, subjects reported that the other person subtracted more points (whether or not that assessment was accurate).

Figure 1 shows the mean number of ratios completed on Button B expressed as a percentage of the mean number of ratios completed at an FR 10. All of the data points represent the mean of the last six sessions at that particular FR value. The mean number of ratios completed at FR 10 were 9.83 for S-364, 31.20 for S-381, 9.17 for S-459, 10.83 for S-480, and 32.8 for S-485. The 2 subjects (S-381 and S-485) who completed the largest number of ratios on the aggressive-response option at the FR 10 response requirement had the largest decreases in the number of ratios completed as the ratio requirement was increased to FR 20, 40, and 80. Subject S-459, who completed the least number of ratios at FR 10, showed only modest decreases in the number of ratios completed as the response requirement was increased. Subject S-480 increased the number of ratios completed when the FR requirement was increased to 20, but with further increases to 40 and 80 the number of ratios completed decreased substantially. Subject S-364 displayed a different pattern; following slight decreases at FR 20, the number of ratios completed increased at FR 40 and increased further at FR 80.

Table 1 lists for each subject the number of sessions required to reach the stability criterion, the number of point-maintained (A) responses per session (including responses spaced by less than 0.17 s), and the net points earned during each session. The number of sessions to reach the stability criterion for aggressive responses was not related to the frequency of aggressive responding. Subjects S-381 and S-485, the subjects who emitted the largest number of aggressive responses under the FR 10 response requirement, took a relatively large number of sessions to reach criterion in the case of S-381 and a relatively small number of sessions in the case of S-485. Subjects who decreased aggressive responding following an increase in the FR requirement (S-381, S-480, and S-485) took fewer sessions to reach the stability criterion.

Point-maintained responding increased in all subjects following the increase in FR requirement for aggressive responding from 10 to 20. Increases in the FR value to 40 and 80 were generally associated with decreased point-maintained responding. A relatively large decrease in point-maintained responding was seen with Subject S-364 (>2,000 responses), who increased the number of ratios completed on the aggressive-response option at a response requirement of FR 80. This rather large decrease in point-maintained responding reflects an increasing allocation of responses to the aggressive option. During the last six sessions at FR 80, S-364 completed an average of 16 ratios, which represents 1,280 aggressive responses per session. The other subjects either slightly increased (200 responses for S-381) or decreased point-maintained responses at FR 80. Net points earned tended to decrease as the FR response requirement on the aggressive response option was increased. This decrease was most evident for Subject S-364, who maintained aggressive responding at FR 80.

Table 1

Fixed-ratio value, number of sessions to criterion, and the means and standard errors of point-maintained responses and net points.

Subject	FR value	Sessions to criterion	Point-maintained responses (±*SEM*)	Net points earned (±*SEM*)
S-364	10	6	6,727 (308)	31.3 (0.8)
	20	24	8,409 (201)	33.7 (1.4)
	10	9	8,206 (360)	33.2 (1.2)
	40	38	7,178 (197)	28.7 (1.2)
	10	24	7,714 (313)	31.8 (1.0)
	80	15	5,542 (174)	24.5 (1.9)
S-381	10	39	5,355 (64)	41.0 (0.7)
	20	18	5,705 (192)	42.2 (1.1)
	10	33	5,574 (65)	44.0 (1.3)
	40	21	5,772 (43)	44.8 (0.8)
	10	15	5,922 (188)	44.7 (2.4)
	80	15	6,135 (230)	40.5 (0.9)
S-459	10	6	6,728 (39)	43.7 (0.9)
	20	41	6,907 (121)	39.5 (1.3)
	10	24	6,971 (278)	46.1 (0.8)
	40	6	7,047 (80)	37.2 (1.2)
	10	10	6,915 (64)	46.0 (1.4)
	80	6	6,542 (50)	39.0 (1.1)
S-480	10	48	6,411 (89)	48.3 (0.9)
	20	26	6,583 (81)	40.0 (1.4)
	40	8	6,252 (123)	42.1 (1.4)
	80	6	5,944 (119)	40.0 (1.7)
S-485	10	11	5,548 (108)	40.1 (0.3)
	20	11	6,018 (76)	47.0 (0.5)
	40	7	5,735 (76)	47.5 (0.8)
	80	7	5,092 (151)	41.3 (1.3)

Discussion

Four of 5 subjects showed a consistent pattern of reducing the number of ratios completed on the aggressive-response option as the response requirement increased. Similar functions have been described for a variety of reinforcing stimuli (e.g., food and drugs: Hodos, 1961; Hodos & Kalman, 1963; Hursh, 1980; Powell, 1969). Subject S-364 consistently increased the number of ratios completed as the response requirement for the aggressive-response option increased. For this subject, the response cost of decreased net earnings was not sufficient to diminish the ability of ostensibly subtracting a point from another subject to serve as a reinforcer. Clearly, there are large individual differences in the ability of retaliatory point subtraction to maintain responding.

EXPERIMENT 2

As discussed above, laboratory research has indicated that the acute administration of alcohol can result in increases in the frequency or intensity of aggressive responding (e.g., Cherek & Steinberg, 1987b). In Experiment 1, aggressive responding decreased as ratio requirement increased. Alcohol may increase aggressive responding by increasing the relative reinforcing effects of aggressive responding. Examining whether aggressive responding persists at increasing FR values following ethanol administration provides an index of the relative reinforcing effects of aggressive responding (Nevin, 1979). Insofar as persistence following increases in response requirement reflects the "strength" (i.e., reinforcing effects) of the operant, then response increases at larger FR values following alcohol administration may reflect increased reinforcing effects of aggressive responding relative to responding maintained by points. Experiment 2 assessed the effect of alcohol (0.125, 0.25, and 0.375 g/kg) on aggressive responding at different response requirements.

METHOD

Subjects and Apparatus

Four males between the ages of 21 and 39 participated after informed consent was obtained. Three of the subjects (S-482, S-527, and S-530) had previously participated in matching-to-sample, number-recall, and pursuit-tracking studies. These subjects reported drinking 3 to 6 oz of alcohol per week.

The apparatus described in Experiment 1 was also used in this experiment.

Procedure

Subjects were recruited, screened, and monitored as discussed in Experiment 1. The same instructions and experimental conditions were employed.

Subjects participated in six daily 25-min sessions at 9:00, 10:00, and 11:00 a.m. and 1:00, 2:00, and 3:00 p.m. Subjects began at an FR 20 response requirement for the aggressive option. After administration of all the alcohol doses, this response requirement was increased to FR 40 and then to FR 80.

At each FR value (20, 40, and 80), subjects were administered several placebo beverages and alcohol doses of 0.125, 0.25, or 0.375 g/kg of 95% alcohol. Placebo drinks contained 2 mL of alcohol floated on the top of 16 oz of tonic water. Placebo or one of the alcohol doses was administered 15 min prior to the first, second, and third sessions of that day. Each drink consisted of alcohol and tonic water in a total volume of 16 oz. During each beverage administration, the 16 oz was divided into three equal portions. The subject was given 3 min to drink each portion. Expired air alcohol content was measured before and after each session.

After each three-session drinking bout (three 16-oz drinks), subjects were asked if they had received alcohol, to estimate the number of "shots" or ounces of alcohol they had consumed, and to estimate the degree of intoxication produced by the drink. Subjects were released at the end of the day, provided they exhibited no signs of intoxication as determined by a standardized assessment procedure and their expired air samples contained less than 20 mg% of alcohol (breath alcohol level = 0.02).

RESULTS

After the last session of each day, subjects reported that they had been paired with one or more individuals. Only Subject S-496 attributed any alcohol effects to the placebo beverages. All subjects reported that a drink had been administered, equivalent to one or more ounces of alcohol, and that the drink was more intoxicating when the dose was 0.25 or 0.375 g/kg of alcohol.

Table 2 provides the means and standard errors of expired breath alcohol levels (BALs) obtained before and after each of the first three sessions. Inspection of this table demonstrates that BALs increased as a function of alcohol dose.

The mean number of ratios completed at FR 20 on Button B under placebo conditions were 13.65 for S-482, 14.93 for S-496, 10.60 for S-527, and 24.06 for S-530. Figure 2 shows the number of ratios completed on the aggressive-response option per session expressed as a percentage of the number completed at FR 20. Only data from the first three sessions of the day are presented. During the three sessions in the afternoon, point-maintained and aggressive responding did not vary as a function of the amount of alcohol consumed in the morning. Presenting data as a percentage of FR 20 baselines allows evaluation of the effects of increasing FR size and alcohol dose. The placebo values represent the mean values for the first three sessions in which subjects received placebo beverages on the days immediately preceding the three alcohol doses. Placebo means are shown for each FR value. Alcohol data points represent the mean of the three sessions in which subjects drank beverages containing 0.125, 0.25, and 0.375 g/kg alcohol.

Table 2

Means and standard errors of expired breath alcohol levels for each subject and dose, measured pre- and postsession.

	Ethanol (g/kg)					
	0.125		0.25		0.375	
Subject	Pre	Post	Pre	Post	Pre	Post
S-482	0.008 (0.004)	0.004 (0.001)	0.035 (0.014)	0.034 (0.016)	0.057 (0.023)	0.056 (0.029)
S-496	0.008 (0.002)	0.003 (0.004)	0.044 (0.007)	0.041 (0.003)	0.034 (0.011)	0.042 (0.014)
S-527	0.010 (0.010)	0.002 (0.010)	0.019 (0.010)	0.016 (0.004)	0.086 (0.019)	0.081 (0.013)
S-530	0.009 (0.004)	0.002 (0.003)	0.036 (0.010)	0.023 (0.009)	0.041 (0.012)	0.037 (0.008)

Examination of the placebo values shows that 3 subjects (S-482, S-496, and S-530) reduced the number of ratios completed as the FR value was increased. At FR 20, these 3 subjects displayed a similar dose–response curve; at 0.125 mg/kg, the number of ratios completed increased substantially (20% to 70%); at the higher doses (0.25 and 0.375 g/kg), the number of ratios completed returned to placebo values or decreased below placebo values. At FR 40, the number of ratios completed increased slightly at the lowest alcohol dose and returned to placebo values or decreased at the 0.25 and 0.375 g/kg doses. At FR 80, Subject S-496 showed little or no change in the number of ratios completed at all three alcohol doses. The other 2 subjects slightly increased the number of ratios completed at the middle alcohol dose and had no change (S-530) or decreased ratios completed at the highest alcohol dose (S-482).

Subject S-527 differed from the other 3 subjects. The mean number of ratios completed under placebo conditions did not decrease as the FR value increased. At FR 20 and FR 40, the number of ratios completed at the middle alcohol dose decreased and the number of ratios completed increased at the highest alcohol dose. At FR 80, increases were noted at the middle dose and few or no changes were seen at the other two alcohol doses.

The number of point-maintained responses and the number of net points earned per session are shown in Table 3. Under placebo conditions, there were orderly decreases in the number of point-maintained responses as the FR value for the aggressive-response option was increased. This reduced point-maintained responding was associated with slight decreases in the number of net points earned for 2 subjects (S-482 and S-496). Subject S-527 had larger decreases in net points earned as the FR value increased, because this subject continued to respond aggressively at higher response requirements. The remaining subject, S-530, had no change in net point earnings as FR value on the aggressive-response option was increased.

Alcohol effects on point-maintained responses at the different FR values for the aggressive-response option were minimal. The only large change in net point earnings, a decrease of 10 points, occurred for Subject S-527 at FR 40 under the high alcohol dose. Under these conditions, Subject S-527 had a large increase in aggressive responding (i.e., an increase in the number of ratios completed on the aggressive-response option).

Discussion

Dose–response effects of alcohol varied among the 4 subjects studied. Three of 4 subjects reduced the number of ratios completed on the aggressive-response option as the response requirement increased. For these subjects, low alcohol doses increased the number of ratios completed when the ratio value was at either 20 or 40. At FR 80, this low alcohol dose no longer had this effect. The middle and high alcohol doses tended to decrease the number of ratios completed, particularly at FR 20 and FR 40. This effect also tended to be reduced at FR 80.

One subject's (S-527) aggressive responding was not affected by increasing the response requirement. This subject completed approximately the same number of ratios under all ratio-requirement conditions. This subject also displayed different effects of alcohol on the aggressive-response option. Low alcohol doses

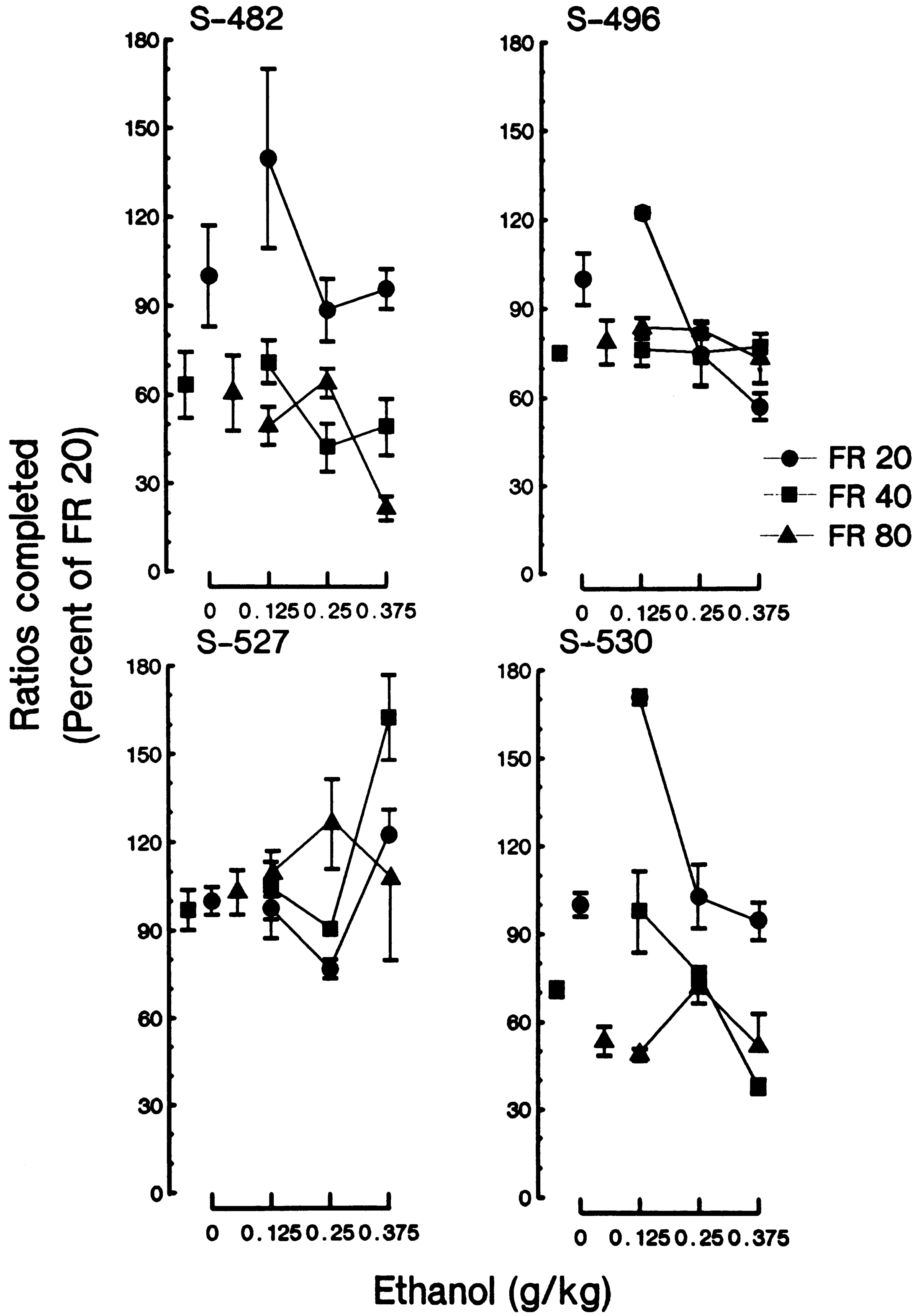
S-482
S-496
S-527
S-530
180
150
120
90
60
30
0
0 0.125 0.25 0.375
FR 20
FR 40
FR 80
Ratios completed
(Percent of FR 20)
Ethanol (g/kg)

Table 3

Within-subject means and standard errors of point-maintained responses and net points earned at each FR value and dose.

		Point-maintained responses				Net points earned			
			Ethanol (g/kg)				Ethanol (g/kg)		
Subject	FR value	Placebo	0.125	0.25	0.375	Placebo	0.125	0.25	0.375
2-482	20	6,605 (147)	6,101 (67)	6,234 (24)	6,285 (73)	45.7 (1.8)	45.3 (0.4)	45.7 (1.8)	45.3 (0.4)
	40	6,394 (189)	6,098 (122)	6,650 (50)	6,168 (61)	45.0 (1.8)	44.7 (1.8)	43.7 (2.1)	43.7 (2.1)
	80	5,997 (168)	6,068 (146)	6,097 (123)	6,254 (137)	43.3 (0.4)	42.0 (2.5)	42.3 (2.8)	39.6 (2.1)
S-496	20	8,065 (279)	7,802 (21)	7,552 (118)	7,619 (206)	32.7 (0.8)	32.0 (0.7)	32.6 (0.4)	33.0 (1.2)
	40	8,032 (83)	8,079 (50)	7,365 (79)	7,870 (55)	32.0 (2.1)	32.6 (1.1)	30.0 (1.4)	33.3 (2.1)
	80	7,546 (60)	7,591 (70)	7,353 (220)	7,144 (151)	30.6 (0.4)	30.6 (0.8)	30.6 (0.8)	29.7 (0.8)
S-527	20	6,416 (72)	6,375 (30)	6,374 (50)	5,827 (233)	46.7 (1.1)	48.0 (0.7)	50.3 (0.4)	45.6 (0.4)
	40	6,167 (59)	6,181 (104)	6,278 (79)	5,974 (307)	47.6 (0.4)	46.6 (1.1)	46.3 (1.6)	37.3 (1.7)
	80	5,953 (165)	5,850 (150)	5,087 (626)	5,441 (429)	39.7 (3.6)	41.0 (1.4)	32.0 (6.1)	41.3 (3.9)
S-530	20	7,379 (262)	7,440 (83)	7,095 (215)	7,130 (159)	35.3 (4.1)	27.3 (1.1)	34.7 (1.6)	35.7 (1.1)
	40	7,031 (193)	6,834 (80)	6,780 (180)	7,296 (111)	36.0 (0.7)	31.3 (0.4)	35.3 (0.4)	36.6 (1.5)
	80	6,400 (114)	6,192 (93)	6,094 (132)	6,480 (332)	37.3 (2.8)	42.0 (1.8)	32.0 (2.8)	36.0 (2.8)

did not increase the number of ratios completed, but the high dose produced increases in the number of ratios completed at FR 20 and FR 40. This effect was essentially eliminated at FR 80.

GENERAL DISCUSSION

Increasing the response requirement for contingent delivery of a variety of stimuli has been used previously to evaluate the relative ability of such stimuli to maintain responding leading to their presentation. In the present experiment, the number of responses required ostensibly to subtract a point from another person (i.e., aggressive responses) was increased to determine whether such responding would be maintained at higher response requirements. For 7 of 9 subjects, increasing the FR requirement for the aggressive-response option produced an orderly decline in the number of ratios completed on that option. Although for most subjects the number of points subtracted diminished with increasing response requirement, the opportunity to subtract points from another person was able to maintain responding following increased requirements. Weiner (1963) reported similar results, with increasing response cost resulting in suppression of responding maintained by avoidance or escape of point loss in a nonsocial context.

Increasing response requirement has been used as a technique to eliminate or reduce response probability. In this experiment, a nonaggressive, point-maintained response option was continuously available. If aggressive responding was maintained under conditions of higher response requirements, then net earnings decreased because more time was allocated to the aggressive-response option (Subject S-364 in Experiment 1 and Subject S-527 in Experiment 2). Thus, for some subjects aggressive retaliation following provocation is sufficiently reinforcing to maintain responding when the response requirement increased and earnings accumulating from a concurrent-response option maintained by point presentation are reduced.

As previously discussed, a recent review (Bushman & Cooper, 1990) of several laboratory studies with humans reported that acute alcohol administration increased aggressive responding. Alcohol doses in the studies reviewed

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Fig. 2. The means (symbol) and standard error (vertical lines) of the percentage change in ratios completed are plotted as a function of ethanol dose. Ratios completed at each dose and for each FR value during the first three sessions are expressed as the percentage of ratios completed during FR 20 requirements for the corresponding placebo sessions.

by Bushman and Cooper (1990) ranged from 0.12 to 0.79 g/kg. They observed no effect of alcohol dose in the analysis of dose differences obtained by combining the results from within- and across-subject studies. However, all differences between responding following alcohol doses and placebo were significant (Bushman & Cooper, 1990). These results and observations from our own laboratory (Cherek & Steinberg, 1987a, 1987b; Kelly et al., 1989) suggest that there are clear individual differences in dose–response curves. Some subjects do not increase aggressive responding, and other subjects decrease aggressive responding following alcohol administration. Our results indicate that the effect of increasing response requirement on aggressive responding may predict the effects of alcohol on such aggressive responding. In Experiment 2, 3 of the 4 subjects decreased aggressive responding following increases in response requirement under placebo conditions. For these 3 subjects, low alcohol doses tended to increase aggressive responding at the FR 20 and FR 40 requirements. Subject S-527, who did not decrease aggressive responding at higher response requirements, increased aggressive responding following the highest alcohol dose at FR 20 and FR 40.

Although the effects of alcohol observed with Subject S-527 could be influenced by the ability of aggressive responding to serve as a reinforcer, they could also represent a decreased sensitivity to alcohol. This decreased sensitivity would result in increases in the number of ratios completed at higher alcohol doses rather than at the low doses, as for the other 3 subjects.

Individual differences were observed in both Experiments 1 and 2. In Experiment 1, 1 subject increased the number of ratios completed on the aggressive-response option following increases in the response requirement. Similarly, in Experiment 2, 1 subject maintained aggressive responding at increased response requirements and increased aggressive responding following administration of the highest alcohol dose, a dose that decreased aggressive responding in the other 3 subjects. For these 2 subjects, the opportunity to retaliate by subtracting a point from another person following provocation was sufficiently reinforcing to maintain or increase responding even after the response requirement for this option was increased and net points earned decreased. The profile of dose effects exhibited by S-527 and S-530 is consistent with explanations of alcohol effects on aggressive responding emphasizing that alcohol alters stimulus control (Bushman & Cooper, 1990; Steele & Josephs, 1990; Zeichner & Pihl, 1979). This explanation suggests that response probability is altered only when conflicting contingencies control the target response during baseline. In Experiment 2, as the response requirement for aggressive responding increased from FR 20 to FR 80, the conflict between control by points and control by (a) subtracting a point from the ostensible other subject and (b) escape from provocation increased especially when aggressive responding during placebo was unaffected by increases in ratio requirement. Therefore, according to stimulus-control explanations, control by immediate events (i.e., provocation) will predominate, and control by remote and competing events (i.e., reduced earnings) will diminish. As a result of decreased control by competing events modulating aggressive responding, the frequency of aggressive responding increases following alcohol administration.

However, the data from S-482 and S-496 are not consistent with disinhibition (Steele & Southwick, 1985) or attentional (Steele & Josephs, 1990; Zeichner & Pihl, 1979) models of alcohol-induced increases in aggressive responding. Instead, our results, consistent with those of other researchers (Gustafson, 1991; Taylor & Sears, 1988), suggest that alcohol-induced increases in aggressive responding are modulated by the environmental context. In the present study, preexperimental histories may have established differential abilities of point subtraction from another person to serve as a reinforcer, which in turn determined the effects of alcohol on such responding.

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