POSITIVE BEHAVIORAL CONTRAST ACROSS FOOD AND ALCOHOL REINFORCERS

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The present study examined behavioral contrast during concurrent and multiple schedules that provided food and alcohol reinforcers. Concurrent-schedule contrast occurred in the responding reinforced by food when alcohol reinforcers were removed. It also occurred in the responding reinforced by alcohol when food was removed. Multiple-schedule contrast appeared for food when alcohol reinforcers were removed, but not for alcohol when food was removed. These results show that behavioral contrast may, but does not always, occur across qualitatively different reinforcers. They also show that multiple-schedule contrast may be more difficult to produce than concurrent-schedule contrast. The results have implications for a model of alcohol consumption.

Key words: behavioral contrast, generality of contrast, alcohol consumption, food reinforcers, alcohol reinforcers, concurrent schedules, multiple schedules, lever press, rats

The present experiments have several objectives. They ask whether behavioral contrast occurs across qualitatively different reinforcers; they compare concurrent-schedule behavioral contrast to multiple-schedule contrast; and they test a model of alcohol consumption.

Contrast across Qualitatively Different Reinforcers

Behavioral contrast refers to an inverse relation between the rates of responding in one component of a concurrent or multiple schedule and the conditions of reinforcement in the other component. Positive contrast refers to an increase in responding maintained by a constant reinforcer that occurs when the other conditions of reinforcement worsen. Negative contrast refers to a decrease in responding maintained by a constant reinforcer that occurs when the other conditions of reinforcement improve. Changes in rates of responding, and in conditions of reinforcement, are frequently assessed relative to a baseline schedule that provides the same conditions of reinforcement in the two components (McSweeney & Norman, 1979).

Studies should examine the generality of

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contrast across qualitatively different reinforcers because different theories have different implications for this issue. Some authors have argued that results may be different when qualitatively different reinforcers are used than when qualitatively similar ones are given (e.g., Hursh, 1980). If this is true, then it cannot be assumed that contrast will occur when the components of a concurrent or multiple schedule provide qualitatively different reinforcers.

Other authors have argued that changes in the value of the reinforcers delivered by one component produce contrast in the other component (e.g., Rachlin, 1973). Characteristics of reinforcers such as their rate, size, immediacy, and quality contribute to their value. If this is so, then reinforcers of different quality may be scaled on a common dimension of reinforcer value, and contrast should occur across qualitatively different reinforcers.

Although many experiments have shown that changes in the rate (e.g., Reynolds, 1961) or size (e.g., Ettinger, McSweeney, & Norman, 1981) of reinforcers produce contrast, few studies have examined reinforcer quality. The studies that have examined this issue fall into two categories.

A few studies have changed the rate of delivery of one type of reinforcer to determine whether contrast occurs in the responding maintained by a different type of reinforcer. In a concurrent-schedule experiment, Matthews and Temple (1979) studied cows when responding was maintained by different types

of food. The rate of responding maintained by hay increased when meal reinforcers decreased. The rate of responding maintained by meal also increased when hay reinforcers decreased. In multiple-schedule studies, Beninger (1972) removed a brain stimulation reinforcer and found that the rate of responding maintained by a constant milk reinforcer increased. Premack (1969) found that bar pressing maintained by water increased when the opportunity to run in an activity wheel was withdrawn. Beninger and Kendall (1975, Experiment 1) also reported that bar pressing maintained by pellets increased when milk was withdrawn, and that bar pressing maintained by milk increased when pellets were withdrawn.

A second type of study varies the quality of reinforcers without changing their rate of delivery. Ettinger *et al.* (1981) found that positive multiple-schedule contrast occurred in responding maintained by a moderately preferred grain when a less preferred grain replaced the moderately preferred grain in the other component. Negative contrast also occurred when a highly preferred grain replaced the moderately preferred grain in the other component. Ettinger and McSweeney (1981) found that the rate of pigeon's water-reinforced key pecking was lower when the other component provided food than when it provided water. But, the rate of responding maintained by food was not different when the other reinforcer was water than when it was food. Higa and McSweeney (1987) replicated these results using rats as subjects, but only when high baseline rates of reinforcement were used.

These experiments support few conclusions about whether contrast occurs across qualitatively different reinforcers. To begin with, the experiments are incomplete. Little is known about concurrent-schedule contrast, and very few different types of reinforcers have been studied. Several of the individual studies may also be criticized. For example, the rate of bar pressing maintained by water increased throughout the session in the Premack (1969) experiment. Therefore, the increase in responding with the removal of the activity wheel may represent either contrast or an increase in responding over time. The increase in responding maintained by milk, reported by Beninger and Kendall (1975) when pellets

were withdrawn, did not occur for all subjects and was small when it did occur. The present experiments examine both concurrent- and multiple-schedule contrast and they study responding maintained by a different type of reinforcer: alcohol.

Concurrent- and Multiple-Schedule Contrast

Behavioral contrast has been observed when subjects respond during concurrent and multiple schedules (e.g., McSweeney, 1975; Reynolds, 1961). Some theories attribute both types of contrast to similar theoretical mechanisms (e.g., Herrnstein, 1970). Other theories attribute them to qualitatively different mechanisms. For example, Rachlin (1973) argued that concurrent-schedule contrast occurs because subjects allocate their time to the components so that the local rates of reinforcement obtained from the components are equal. Multiple-schedule contrast occurs because responses controlled by the stimulus-reinforcer relation interact with responses controlled by the response-reinforcer relation.

The question of whether similar theoretical mechanisms govern concurrent- and multiple-schedule contrast is important because theories of schedule performance would be simplified if the same factors did govern behavior on the two schedules. But, in spite of its importance, few data bear on this question. Some data suggest that multiple-schedule contrast is more difficult to produce than concurrent-schedule contrast (e.g., McSweeney, 1975; 1978), but these comparisons are made across studies. The two types of contrast are usually not examined in the same study. The present experiments examine both concurrent- and multiple-schedule contrast to determine whether the two types of contrast occur under similar conditions.

A Model of Alcohol Consumption

Positive behavioral contrast is a sudden increase in a behavior that occurs when the reinforcement for that behavior remains unchanged. Therefore, contrast might serve as a model for, or a contributing factor to, sudden changes in a behavior that are not directly produced by changes in the reinforcement for that behavior. For example, it might provide a model of some increases in alcohol consumption. A contrast model of alcohol consumption might argue that the frequency of

drinking increases when reinforcers are lost for other behavior in other situations (positive contrast).

This idea is highly speculative, but some characteristics of alcohol consumption are compatible with the model. For example, some data suggest that higher alcohol consumption occurs in situations that intuitively seem to provide lower rates of alternative reinforcers. Drinking may increase among women when children leave the home (Curlee, 1969). Heavy drinking is associated with low socioeconomic status (e.g., Cahalan, Cisin, & Crossley, 1969), and with membership in disadvantaged groups (e.g., Malzberg, 1963). It is correlated with growing up in homes that are broken or irresponsible (Robins & Guze, 1970). It may increase in the general population at times of loss (e.g., Zinberg & Fraser, 1979). Finally, it is correlated with not living with a spouse or relative (e.g., Carman, 1981). Although these data are correlational and speculative, they are consistent with the model.

Laboratory studies of contrast also lend plausibility to the model. Alcohol is known to be a reinforcer (e.g., Poling & Thompson, 1977). Therefore, behavior that produces it, such as drinking, may be subject to behavioral contrast. Contrast has been shown to occur when people serve as subjects (e.g., Waite & Osborne, 1972), and when responding is observed in applied settings (e.g., Gross & Drabman, 1981). Contrast effects may be large: Increases in response rates as large as 50 to 100% have been reported (e.g., Hearst & Gormley, 1976; McSweeney & Melville, 1988). As just mentioned, contrast has also been observed for responding for one reinforcer when another reinforcer is withdrawn (e.g., Beninger & Kendall, 1975) and has been observed across different responses (e.g., Beninger & Kendall, 1975). These results make it more plausible that the loss of other reinforcers might lead to an increase in drinking, as argued by the model.

Although this model may provide an account of some alcohol consumption, it cannot be a complete model. For example, the contrast model cannot explain the role of genetic factors (e.g., Goodwin, 1979). It cannot explain why some people lose jobs or family members without drinking heavily or why some people drink heavily in spite of having a job or family. Fi-

nally, it cannot explain why the first drink is taken. However, the contrast model is not alone in its incompleteness. Many believe that alcohol consumption is multiply determined, and therefore, no single explanation may ever account for all drinking (e.g., Mello & Mendelson, 1978).

If contrast is to serve as a model for some alcohol consumption, then it must be shown that contrast occurs in the responding maintained by an alcohol reinforcer when another, qualitatively different, reinforcer is withdrawn. The present experiments attempt to do this.

EXPERIMENT 1

Experiment 1 uses a concurrent schedule to examine contrast with food reinforcers when alcohol reinforcers are withdrawn and contrast with alcohol reinforcers when food is withdrawn. This experiment, and those that follow, use a within-session procedure to measure contrast. Most studies of contrast use an across-sessions procedure; that is they conduct a baseline schedule in which both components provide the same conditions of reinforcement, and then present a contrast schedule in which the conditions of reinforcement in one component are changed. Then, they recover baseline (e.g., McSweeney, Dougan, Higa, & Farmer, 1986).

The across-sessions procedure has two problems. First, it requires many sessions to conduct. Each measurement of contrast requires conducting three schedules, each of which requires 30 to 40 sessions. Second, fluctuations in responding that occur over these long periods confound the measurement of contrast. Rates of responding may double from one baseline schedule to its recovery (e.g., McSweeney et al., 1986; Spealman & Gollub, 1974).

In the present experiments, we used a procedure that reduces these problems. The within-session procedure measures baseline and contrast in a single session. Therefore, both the amount of time required to measure contrast and the fluctuations in responding that occur over time are reduced.

This procedure has been used here because other authors have successfully used a within-session procedure to study performance on other schedules (e.g., Heyman, 1983). Mc-

Table 1

Mean rates of responding (R) and reinforcement (SR), in responses or reinforcers per minute, emitted or obtained by each subject during each component of each concurrent schedule in Experiment 1.

Subject	Component	Schedule					
		Baseline		Alcohol on ext		Food on ext	
		R	SR	R	SR	R	SR
61	Food	54.5	1.9	62.5	2.0	5.1	0.0
	Alcohol	3.7	0.5	1.1	0.0	7.8	1.0
62	Food	37.7	1.5	47.8	1.9	18.8	0.0
	Alcohol	2.6	0.7	0.2	0.0	8.0	1.0
63	Food	24.9	1.2	37.8	1.4	20.0	0.0
	Alcohol	8.6	1.0	6.5	0.0	11.0	1.0
64	Food	61.8	1.5	66.0	1.5	29.1	0.0
	Alcohol	0.8	0.4	0.0	0.0	3.0	0.4
65	Food	33.7	1.6	35.6	1.5	27.2	0.0
	Alcohol	1.9	0.3	1.5	0.0	1.4	0.2
Mean	Food	42.5	1.5	49.9	1.7	20.0	0.0
	Alcohol	3.5	0.6	1.9	0.0	6.2	0.7

Sweeney and Melville (1988) have also provided a strong test of the similarity of the across- and within-session procedures. They showed that the within-schedule procedure produces multiple-schedule contrast and that similar functions relate the size of contrast to component duration for the within- and across-sessions procedures.

Method

Subjects. Five rats bred in the Johnson Tower Animal colony at Washington State University served as subjects. The rats were approximately 120 days old at the start of the experiment. They were maintained at 90% of their free-feeding body weights and were given 15 min of access to water after every session.

Apparatus. The apparatus was a standard operant conditioning unit for rats, 23.5 by 19 by 30 cm. Two 5.5 by 1.5 cm response levers were located 7 cm from the floor and 5 cm from each side of the apparatus. The levers were connected to microswitches that required approximately 0.3 N to operate. Lights (2.5 cm diameter) were located 0.5 cm from each side of the apparatus and 8.5 cm above the floor. The left light was red; the right was green. A third white light was located 4 cm from the ceiling and was spaced evenly between the sides. This third light was used as a houselight and was illuminated during the session.

A food trough (4 by 4.5 by 2 cm), located 1 cm from the floor and 12.5 cm from the right side of the apparatus, presented the Noyes pellets that served as food reinforcers. A hole 5 cm in diameter located 2 cm from the right side of the apparatus and 1 cm above the floor allowed access to a 0.5-mL dipper.

The experimental enclosure was housed in a sound-attenuating chamber. A ventilating fan masked noises from outside the chamber. Experimental events were programmed by a SYM® microcomputer located in another room.

Procedure. Subjects were trained to press both levers with water reinforcers by a shaping by successive approximations procedure. Once they began to press they were placed on a concurrent schedule that provided high rates of water reinforcement for pressing the right lever and high rates of food reinforcement for pressing the left lever. Then, alcohol was added gradually to the water until the subjects' responses were maintained by a solution consisting of 10% alcohol by volume. Finally, rates of reinforcement were reduced gradually until subjects responded on a concurrent variable interval (VI) 30-s VI 30-s schedule.

During the experiment, subjects began each session by responding on a concurrent VI 30-s VI 30-s schedule. Reinforcers were scheduled according to a 25-interval series constructed according to the procedure suggested by Flesh-

ler and Hoffman (1962). Reinforcers for the two components were presented by schedules which operated independently of each other. A 3-s changeover delay (COD), during which no reinforcers could be obtained, was scheduled whenever subjects changed from one component to the other.

Alcohol reinforcers were obtained by pressing the right lever; food reinforcers were obtained by pressing the left lever. Alcohol reinforcers consisted of 5-s access to the 0.5-mL dipper containing the 10% alcohol solution. Food reinforcers consisted of one 45-mg Noyes pellet. The lights over the levers were turned off for 5 s whenever either reinforcer was delivered.

After 15 min, the schedule changed to a concurrent VI 30-s extinction (ext) schedule. Subjects still obtained food by pressing the left lever, but no alcohol reinforcers were available. After another 15 min, the schedule changed to a concurrent ext VI 30 s. Subjects could obtain alcohol reinforcers by pressing the right lever, but no food was available.

During the session, the houselight and the left and right lights were illuminated. Five-second timeouts, during which the left and right lights were extinguished, occurred as a transition from one schedule to the next within the session.

Subjects responded on this procedure until responding stabilized. Responding was considered stable when no upward or downward trends appeared in the data. To determine this, mean rates of responding were calculated for each subject responding on each component of each schedule. Responding was considered stable when each of these response rates emitted during each of the last five sessions fell within the range of the rates of responding emitted during that component in all previous sessions. Achieving stability required an average of 21.2 sessions for all subjects.

Results and Discussion

Table 1 contains the mean rates of responding emitted by, and the mean rates of reinforcement obtained by, each subject during each component of each concurrent schedule. These rates are the means of the rates emitted over the last five sessions. They were calculated by dividing the number of responses emitted, or the number of reinforcers obtained during each component by the total session time minus the

time for which reinforcers were available. Rates are reported in responses or reinforcers per minute.

The data in Table 1 support several conclusions. First, the procedure exerted good control over behavior. Rates of responding emitted on both levers decreased when the reinforcers produced by those responses were withdrawn. t tests for matched pairs will be used throughout this paper to determine statistical significance, and significance will be defined by $p < .05$. Using these criteria, the rate of responding maintained by food decreased significantly when food reinforcers were withdrawn, $t(4) = 2.68$. The rate of responding maintained by alcohol decreased significantly when alcohol reinforcers were withdrawn, $t(4) = 3.73$.

Second, food reinforcers maintained more responding than did alcohol reinforcers. Subjects obtained more food than alcohol reinforcers even during the baseline schedule, which programmed equal rates of reinforcement for the two components, $t(4) = 4.45$. Responding maintained by food was also faster than responding maintained by alcohol during baseline, $t(4) = 5.02$.

Third, the rate of responding maintained by food increased when alcohol reinforcers were withdrawn, $t(4) = 3.75$. This increase occurred even though the rate of food reinforcement produced by this responding did not change between phases, $t(4) = 1.40$.

Finally, the rate of responding maintained by alcohol increased significantly when food was withdrawn, $t(4) = 2.73$. This increase also occurred even though the rate of alcohol reinforcement produced by this responding did not change, $t(4) = 1.25$.

These results indicate that positive contrast occurred in the responding maintained by food when alcohol reinforcers were withdrawn. Positive contrast also occurred for alcohol when food reinforcers were withdrawn. Contrast is a change in the rate of responding maintained by a constant reinforcer with changes in the rate of reinforcement produced by responding in the other component. The present results fit this description: An increase in the rate of responding maintained by food was observed when alcohol reinforcers were withdrawn even though the rate of food reinforcement remained constant, and an increase in the rate of responding maintained by alcohol was ob-

served when food was withdrawn even though the rate of alcohol reinforcement remained constant.

The fact that equal rates of reinforcement were not obtained during the two components of the baseline schedule does not change this interpretation. Most theories of contrast do not require the presentation of a baseline delivering equal rates of reinforcement for the production of contrast (e.g., Herrnstein, 1970), and many empirical studies of contrast do not establish such a baseline (e.g., Williams, 1988).

EXPERIMENT 2

In Experiment 2, we examined multiple-schedule behavioral contrast using food and alcohol reinforcers.

Method

Subjects. Four rats bred in the Johnson Tower Animal Colony served as subjects. They were approximately 120 days old at the start of the experiment. A fifth subject started the experiment but became sick and did not finish. Subjects were maintained at the same food and water deprivations used in Experiment 1.

Apparatus and procedure. The apparatus used in Experiment 1 was used here. A similar within-session procedure was also used. Subjects were trained to press both levers by a shaping by successive approximations procedure using water reinforcers. Once they pressed, a multiple schedule was introduced that provided high rates of water reinforcement for pressing the right lever and high rates of food reinforcement for pressing the left lever. Then, alcohol was added gradually to the water until presses were maintained by a 10% alcohol solution. Finally, the rates of reinforcement were lowered gradually until subjects responded on a multiple VI 30-s VI 30-s schedule.

Subjects began each session by responding on a multiple VI 30-s VI 30-s schedule. Food reinforcers were collected by pressing on the left lever, alcohol reinforcers by pressing on the right lever. The components alternated every 30 s, and the left and right lights signaled when each component was available. Reinforcers that became available but were not collected before the change of components were held over for collection during the next appearance of that component.

After 30 components had been presented (15 min), the schedule changed to a multiple VI 30-s ext schedule in which alcohol reinforcers were withdrawn but food reinforcers were still available during the food component. After 30 more components had been presented, the schedule became a multiple ext VI 30-s schedule in which food was withdrawn but alcohol was still available in the alcohol component.

All other procedural details were the same as those for Experiment 1. An average of 52.8 sessions was required to obtain stable responding.

Results and Discussion

Table 2 contains the mean rates of responding emitted by, and the mean rates of reinforcement obtained by, each subject during each component of each multiple schedule. The rates are the means of the rates emitted during the last five sessions for which each schedule was available. Rates were calculated by dividing the number of responses emitted, or the number of reinforcers obtained, during a component by the time for which that component was available minus the time for which reinforcers were presented. Rates are reported as responses or reinforcers per minute.

The data in Table 2 show that the schedules exerted good control over behavior. The rate of food-maintained responding decreased significantly when food was placed on extinction, $t(3) = 3.30$. The rate of alcohol-maintained responding decreased significantly when alcohol was placed on extinction, $t(3) = 8.51$.

Food reinforcement maintained a higher rate of responding than alcohol reinforcement during the baseline schedule, but the difference between these rates did not reach statistical significance, $t(3) = 2.17$. The rates of reinforcement obtained during the two components during baseline also approached but did not reach significance $t(3) = 2.33$.

Positive contrast occurred in the responding maintained by food when alcohol reinforcers were removed. The rate of responding maintained by food increased significantly from the baseline to the schedule that placed alcohol on extinction, $t(3) = 4.49$. This increase occurred even though the obtained rate of food reinforcement remained unchanged when alcohol was removed, $t(3) = 2.05$.

Finally, contrast did not occur in the responding maintained by alcohol when food was

Table 2

Mean rates of responding (R) and reinforcement (SR), in responses or reinforcers per minute, emitted or obtained by each subject during each component of each multiple schedule in Experiment 2.

Subject	Component	Schedule					
		Baseline		Alcohol on ext		Food on ext	
		R	SR	R	SR	R	SR
401	Food	33.3	1.2	46.4	1.6	9.4	0.0
	Alcohol	3.5	1.1	1.5	0.0	3.4	1.0
402	Food	7.6	1.4	15.1	1.6	3.1	0.0
	Alcohol	5.0	1.4	2.2	0.0	5.8	1.2
403	Food	15.1	1.6	23.2	1.7	2.2	0.0
	Alcohol	4.1	1.3	2.0	0.0	2.9	1.7
405	Food	13.0	1.6	17.3	1.6	1.4	0.0
	Alcohol	5.0	1.3	3.4	0.0	2.6	1.0
Mean	Food	17.3	1.5	25.5	1.6	4.0	0.0
	Alcohol	4.4	1.3	2.3	0.0	3.7	1.2

removed. Responding maintained by alcohol did not increase when subjects moved from the baseline to the schedule that placed food on extinction, $t(3) = 1.05$. The obtained rate of alcohol reinforcement also did not change when food was removed, $t(3) = 0.32$.

EXPERIMENT 3

The results of Experiment 2 may indicate that multiple-schedule contrast does not occur for alcohol reinforcers when food is withdrawn. Alternatively, they may represent a general decline in responding maintained by alcohol reinforcers over the session.

The data in Table 1 cast doubt on the idea that responding maintained by alcohol reinforcers declined over the session. Sessions were the same length in Experiment 1 as in Experiment 2, but the rate of responding was greater during the alcohol component in the third part of the session in Experiment 1 than it was during that component in either of the two earlier parts. However, to be sure that the failure to find contrast in Experiment 2 was not produced by a decline in responding over the session, Experiment 3 replicated Experiment 2 using a shorter session.

Methods

Subjects. The subjects were five rats, approximately 120 days old, obtained from the Johnson Tower Animal Colony. They were

studied using the same conditions of deprivation as in Experiments 1 and 2.

Apparatus and procedure. The apparatus was the same as that used for Experiments 1 and 2.

Subjects were accustomed to drinking alcohol and were trained to press the levers by the same procedure used in Experiment 2. They were then exposed to a procedure identical to that used in Experiment 2 except that only two schedules were conducted per session. The first schedule was a baseline multiple VI 30-s VI 30-s schedule that provided food reinforcers when subjects pressed the left lever and alcohol reinforcers when they pressed the right lever. This schedule was in effect until 30 30-s components had been presented. It was followed by a multiple ext VI 30-s schedule in which no food reinforcers were provided but alcohol reinforcers were still available during the alcohol component. This schedule was also in effect until 30 30-s components had been presented. All other procedural details were identical to Experiment 2. An average of 42.2 sessions was required to produce stable responding.

Results and Discussion

The subjects in this experiment did not always obtain the same number of alcohol reinforcers during the baseline and contrast phases. Sessions in which this happened could not be used to assess contrast because contrast requires that the rate of reinforcement in one

Table 3

Mean rates of responding (R) and reinforcement (SR), in responses or reinforcers per minute, emitted or obtained by each subject during each component of each multiple schedule in Experiment 3.

Subject	Component	Schedule			
		Baseline		Food on ext	
		R	SR	R	SR
601	Food	32.0	1.7	9.3	0.0
	Alcohol	8.3	1.4	5.7	1.2
602	Food	45.8	2.0	10.0	0.0
	Alcohol	2.9	1.1	1.3	0.4
603	Food	10.6	1.0	2.1	0.0
	Alcohol	5.0	1.4	4.8	1.6
604	Food	12.2	1.2	5.1	0.0
	Alcohol	6.6	1.3	3.9	1.2
605	Food	5.8	1.5	2.7	0.0
	Alcohol	2.4	0.8	2.1	0.9
Mean	Food	21.3	1.5	5.8	0.0
	Alcohol	5.0	1.2	3.6	1.1

component be held constant from the baseline to the contrast phase. To avoid this problem, the last five sessions were identified in which the subjects obtained a similar number of alcohol reinforcers in the baseline and contrast phases. Usually such sessions could be found among the last seven or eight sessions that were conducted. In no case were any data included until the subject had responded for at least 25 sessions.

Table 3 presents the data from these sessions. It presents the mean rates of responding emitted by and the mean rates of reinforcement obtained by, each subject during each component of each multiple schedule. Rates were calculated as they were for Experiment 2 and are reported as responses or reinforcers per minute.

Table 3 shows that food reinforcement maintained more responding than did alcohol reinforcement. The obtained rates of food and alcohol reinforcement were not significantly different during baseline, $t(4) = 1.16$, but these similar rates of reinforcement maintained different rates of responding. The rate of responding maintained by food was significantly greater than the rate of responding maintained by alcohol, $t(4) = 2.14$.

The procedure exerted good control over behavior. The rate of responding maintained by food decreased significantly when food was

no longer delivered, $t(4) = 2.54$, but induction was observed instead of positive contrast. The rate of responding maintained by alcohol decreased significantly when food was withdrawn, $t(4) = 2.75$, even though the rate of alcohol reinforcement produced by this responding remained unchanged, $t(4) = 0.89$.

EXPERIMENT 4

Dougan, McSweeney, and Farmer (1985) found behavioral contrast when bar pressing was maintained by food reinforcers, but only when the components of the baseline multiple schedule provided very high rates of reinforcement. Higa and McSweeney (1987) also found contrast across reinforcers only at high rates of reinforcement. Although high rates of reinforcement were used in Experiments 2 and 3, they were not as high as those used in the studies that reported contrast. Experiment 4 replicates Experiment 3 using a higher rate of reinforcement.

Method

Subjects. The same subjects used in Experiment 3 also served here under the same conditions of deprivation.

Apparatus and procedure. The apparatus was the same one used in the preceding experiments. The procedure was also identical to that of Experiment 3 except that a multiple VI 15-s VI 15-s schedule served as baseline. A multiple VI 15-s (alcohol) ext (food) schedule was presented in the contrast phase. An average of 39.0 sessions was conducted.

Results and Discussion

As in Experiment 3, subjects did not always collect the same number of alcohol reinforcers in the baseline and contrast phases. Because the measurement of contrast requires that the same number of reinforcers be obtained, the last five sessions were sought in which the subjects did obtain a similar number of alcohol reinforcers in the baseline and contrast phases. Again, usually such sessions could be found among the last seven or eight sessions. In no case were any data included until the subject had responded for at least 25 sessions.

The data from these sessions are presented in Table 4. The table presents the mean rates of responding emitted by, and the mean rates of reinforcement obtained by, each subject dur-

ing each component of each multiple schedule. Rates were calculated as for Experiment 2 and are reported as responses or reinforcers per minute.

A comparison of Tables 3 and 4 shows that the rates of reinforcement obtained in Experiment 4 were greater than those obtained in Experiment 3. The rates of reinforcement obtained during baseline in Experiment 4 were significantly greater than the rates obtained in Experiment 3 for the food, $t(4) = 3.07$, and alcohol, $t(4) = 2.46$, components. The rates of reinforcement obtained from the alcohol component of the contrast schedules were also greater in Experiment 4 than in Experiment 3, $t(4) = 2.42$.

Table 4 shows that food maintained more responding than did alcohol. The obtained rates of reinforcement were greater for food than for alcohol during baseline even when the same rates of reinforcement were programmed for the two components, $t(4) = 5.48$. Responding maintained by food was also significantly faster than responding maintained by alcohol during baseline, $t(4) = 2.19$.

Again, the procedure exerted good control over behavior. The rate of responding maintained by food decreased significantly when no food was delivered, $t(4) = 2.45$. However, positive contrast was not observed: The rate of responding maintained by alcohol reinforcement did not increase significantly when food was withdrawn, $t(4) = 0.48$. The rate of alcohol reinforcement obtained by this responding also remained unchanged when food was withdrawn, $t(4) = 0.0$.

EXPERIMENT 5

The preceding experiments failed to find multiple-schedule contrast in the responding maintained by alcohol reinforcers when food reinforcers were removed. This may cast doubt on the model of alcohol consumption proposed earlier. That model argues that drinking increases when other, successively available, reinforcers are withdrawn. Alternatively, the results may call into question whether a multiple VI VI schedule provides a good model for this real-world situation.

In the real world, a person who increases his drinking when he loses his job actually consumes more alcohol per time unit than he did previously. The present multiple VI VI

Table 4

Mean rates of responding (R) and reinforcement (SR), in responses or reinforcers per minute, emitted or obtained by each subject during each component of each multiple schedule in Experiment 4.

Subject	Component	Schedule			
		Baseline		Food on ext	
		R	SR	R	SR
601	Food	69.6	3.4	14.8	0.0
	Alcohol	24.2	3.1	38.0	2.8
602	Food	55.8	2.7	7.8	0.0
	Alcohol	14.6	2.5	12.2	2.4
603	Food	6.7	1.4	1.3	0.0
	Alcohol	2.7	1.2	3.4	1.4
604	Food	21.5	2.5	4.1	0.0
	Alcohol	13.4	2.2	9.3	2.2
605	Food	6.7	1.7	2.0	0.0
	Alcohol	2.8	1.2	2.4	1.3
Mean	Food	32.1	2.3	6.0	0.0
	Alcohol	11.5	2.0	13.1	2.0

schedules do not permit an increase in the consumption of alcohol when food is withdrawn. Even if rates of alcohol-maintained responding increase when food is withdrawn, subjects cannot obtain many more alcohol reinforcers per time unit. The rate of reinforcement provided by a VI schedule is relatively insensitive to large changes in the rate of responding.

A multiple variable-ratio (VR) VR schedule might provide a more realistic model. Increases in responding on ratio schedules produce proportional increases in the obtained rates of reinforcement. Therefore, an increase in alcohol-maintained responding that occurred when food reinforcers were withdrawn would also result in more alcohol reinforcers per time unit on this schedule.

To test this idea, the present experiment studied changes in responding on a multiple VR (food) VR (alcohol) schedule when food reinforcers are withdrawn. This experiment cannot examine behavioral contrast. Contrast represents a change in the rate of responding maintained by a *constant* rate of reinforcement that occurs when the reinforcement provided by the other component changes. Because changes in the rate of alcohol-maintained responding provided by VR schedules change the rate of alcohol reinforcement, the rate of reinforcement is not held constant and contrast cannot be studied.

Table 5

Mean rates of responding, in responses per minute, emitted by each subject in each component of each multiple schedule in Experiment 5.

Subject	Component	Schedule		
		Baseline	Food on ext	Alcohol on ext
31	Food	87.5	6.6	110.2
	Alcohol	24.8	32.4	0.6
32	Food	74.3	9.5	73.4
	Alcohol	72.7	33.0	2.6
33	Food	—	—	—
	Alcohol	—	—	—
34	Food	41.7	20.2	64.9
	Alcohol	75.1	55.0	6.6
35	Food	—	—	—
	Alcohol	—	—	—
Mean	Food	67.8	12.1	82.8
	Alcohol	57.5	40.1	3.3

Method

Subjects. Five rats bred in the Johnson Tower Animal Colony at Washington State University served as subjects. The rats were approximately 120 days old at the start of the experiment and were maintained at approximately 90% of their free-feeding body weights. They were given 15 min of access to water after every session.

Apparatus and procedure. The same apparatus used in the preceding experiments was used here. The procedure was also identical to that used in Experiment 2 except that a multiple VR 30 VR 30 schedule served as baseline. After 30 components (15 min) this was replaced by a multiple ext (food) VR 30 (alcohol) schedule. After 30 components, this was replaced by a multiple VR 30 (food) ext (alcohol) schedule. The VR schedules were programmed according to a 25-interval series constructed by the method suggested by Flesher and Hoffman (1962). An average of 86 sessions was required to obtain stable responding.

Results and Discussion

As in the preceding experiments, subjects did not always collect reinforcers when they were programmed. Therefore, the last five sessions were sought in which subjects obtained some reinforcers in all of the components for which they were programmed. In all cases,

subjects had responded on the same schedule for at least 25 sessions before any data were taken.

The data from these sessions are presented in Table 5. The table presents the mean rates of responding, as presses per minute, emitted by each subject during each component of each multiple schedule. Rates were calculated as for Experiment 2. Rates of reinforcement are not reported because they are directly proportional to rates of responding on ratio schedules.

Table 5 shows that Subjects 33 and 35 did not respond on these schedules. However, for the 3 subjects that did respond, the procedure exerted good control over behavior. Responding maintained by food decreased when food was placed on extinction, $t(2) = 3.14$. Responding maintained by alcohol decreased when alcohol was placed on extinction, $t(2) = 3.61$, but responding maintained by alcohol did not increase when food was placed on extinction, $t(2) = 1.27$. Responding maintained by food did not increase when alcohol was placed on extinction, $t(2) = 1.89$.

GENERAL DISCUSSION

Contrast across Reinforcers

The present experiments revealed behavioral contrast across qualitatively different reinforcers when subjects responded on concurrent schedules. Experiment 1 showed that the removal of food reinforcers produced positive concurrent-schedule contrast in the responding maintained by alcohol. The removal of alcohol also produced positive concurrent-schedule contrast in the responding maintained by food. These changes in response rates occurred even though the rates of reinforcement produced by those responses were unchanged when the alternative reinforcer was withdrawn.

The present experiments also found some contrast across qualitatively different reinforcers when subjects responded on multiple schedules. Experiment 2 showed that multiple-schedule contrast occurred for food reinforcers when alcohol reinforcers were removed. These results are consistent with those of Beninger and Kendall (1975), who found contrast in responding maintained by pellets when milk was withdrawn. They are also consistent with the results of Ettinger and McSweeney (1981) and Higa and McSweeney

(1987) who found a decrease in responding maintained by water when the reinforcers delivered by the other component changed from water to food.

However, Experiments 2, 3, 4, and 5 show that multiple-schedule contrast is not always observed across qualitatively different reinforcers. The rate of responding maintained by alcohol did not increase, and sometimes decreased (Experiment 3), when food was removed. This result resembles that of Beninger and Kendall (1975), who found only small and inconsistent increases in the rate of responding maintained by milk when pellets were withdrawn. It also resembles results reported by Ettinger and McSweeney (1981) and by Higa and McSweeney (1987), who found that the rate of responding maintained by food did not change when the reinforcer provided by the other component changed from food to water.

The results of these studies do not fit an obvious pattern. For example, the results of the present experiments and those of Beninger and Kendall (1975) suggest that contrast is hard to produce when liquid reinforcers are used. But, the results reported by Ettinger and McSweeney (1981) and by Higa and McSweeney (1987) suggest the opposite. Those authors found contrast in responding maintained by water but not in responding maintained by food. Beninger (1972) also reported contrast when liquid reinforcers were used.

Because the results involved food and liquid reinforcers, it might also be argued that they are affected by the biological food-liquid interactions for the species under study. But again, the results do not fit this hypothesis. The present experiments and those of Beninger and Kendall (1975), which found little or no contrast for liquid reinforcers, used rats as subjects. But the study by Higa and McSweeney (1987), which reported contrast for water reinforcers, also used rats. The studies by Ettinger and McSweeney (1981) and by Higa and McSweeney (1987), which reported similar results across food and water reinforcers, used two species (rats and pigeons) that differ considerably in the biology of their food-water interactions.

The present results are consistent with theories arguing that different results may be observed when the components of a complex schedule provide qualitatively different reinforcers than when they provide qualitatively

similar reinforcers (e.g., Hursh, 1980). Behavioral contrast appears consistently when qualitatively similar reinforcers are used (e.g., Williams, 1983), although some effort may be required to demonstrate multiple-schedule contrast for some responses (cf. Hemmes, 1973; McSweeney et al., 1986). The present results and those of other studies show that contrast may fail to occur when qualitatively different reinforcers are used (Ettinger & McSweeney, 1981; Higa & McSweeney, 1987). Therefore, they support the idea that results may differ when qualitatively similar and different reinforcers are used.

The present results also contradict the ideas that the quality of a reinforcer contributes to its value and that changes in the value of the reinforcers provided by one component produce behavioral contrast in the other component (e.g., Rachlin, 1973). If this were so, then reinforcers of different quality should have been scalable on a common dimension of value, and contrast should have occurred consistently in all of these experiments. However, multiple-schedule contrast frequently failed to occur.

These conclusions should be considered with caution, however. Stronger conclusions could be drawn from the present experiments if baseline had been recovered after the contrast phases. Baseline was not recovered because this would have made the sessions too long. The present procedure represents an empirically derived compromise between conducting each part of the session long enough to obtain clear data and keeping each part short enough so that changes in response rates would not occur across the session. In order to recover baseline after the contrast phases, either the sessions would have been lengthened, creating problems with changing response rates, or each phase would have been shortened, producing unstable data.

Several properties of the present data suggest that the failure to observe multiple-schedule contrast cannot be attributed to the failure to recover baseline. If changes in response rates within the session did obscure the observation of contrast, then contrast should not have been observed for the concurrent schedules that used the same session duration as the multiple schedules in Experiment 2. But, contrast was observed for concurrent schedules. Multiple-schedule contrast also failed to occur in Experiment 3 even though short sessions were

conducted in that experiment. The use of short sessions makes it less likely that changes in response rates occurred within the session. Had it been possible, however, it would have been preferable to have recovered baseline after the contrast phases.

Drawing strong conclusions should also await the collection of more data. Future studies may reveal a procedural reason for the present failure to observe multiple-schedule contrast. Such studies may determine whether qualitatively similar and different reinforcers govern behavior differently. Future studies may also reveal a consistent pattern of situations in which contrast occurs and does not occur.

Concurrent- and Multiple-Schedule Contrast

The present results reported a difference between concurrent- and multiple-schedule behavioral contrast. Contrast was reported consistently for concurrent schedules but not for multiple schedules. The failure to find contrast on multiple schedules occurred in spite of several attempts to produce it.

These results add to those of other studies that failed to find multiple-schedule contrast in situations similar to those that produce concurrent-schedule contrast (e.g., McSweeney, 1975, 1978). Although a single explanation for both multiple- and concurrent-schedule contrast may be formulated eventually, the present pattern of results favors theories that attribute the two types of contrast to different factors (e.g., Rachlin, 1973) over those that attribute them to similar factors (e.g., Herrnstein, 1970).

A Model of Alcohol Consumption

The present results both support and limit the proposed model of alcohol consumption. Experiment 1, which found increases in responding maintained by alcohol when food was withdrawn, supports the model when reinforcers are available concurrently. Experiments 2, 3, 4, and 5, which failed to find increases in responding maintained by alcohol reinforcers when food was removed, fail to support the model when reinforcers are successively available. Experiment 5 showed that this failure was not produced by the inability of the animals to increase their rate of alcohol consumption during the multiple VI ext schedules. Responding also failed to increase for alcohol reinforcers presented on VR schedules

when successively presented food reinforcers were withdrawn.

The results of Experiments 2, 3, 4 and 5, should be interpreted carefully. Past experience indicates that multiple-schedule contrast may ultimately be observed where it has not appeared in the past (e.g., Hemmes, 1973; McSweeney, 1978). However, for now, the results imply that the contrast model of alcohol consumption may apply when a reinforcer that was concurrently available with alcohol is lost, but not when a reinforcer that was successively available with alcohol is lost.

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