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ORIGINAL INVESTIGATION

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Inelastic demand for alcohol in rats

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Abstract *Rationale:* For the purpose of investigating the determinants of preference for alcohol, it would be advantageous to use a procedure in which the subjects had concurrent access to alcohol and an isocaloric food. However, in widely used animal models, the introduction of a weak sucrose solution markedly reduced alcohol consumption. In contrast, when alcohol was sweetened, rats defended high baseline levels of alcohol intake despite access to chow, 10% sucrose, and increases in body weight that markedly reduced food consumption. Under these conditions, certain pharmacological treatments selectively reduced alcohol consumption. The present experiment further tests the generality of the contrast between food and sweetened alcohol consumption in rats. *Objective*: To test if rats will defend baseline levels of alcohol consumption when (1) the competing reinforcer is an isocaloric, preferred food and (2) when the cost of defending alcohol entails a decrease in food consumption as well as an increase in response output. *Methods:* The rats had access to a 10% alcohol plus 0.25% saccharin solution and an isocaloric, 14.8% Polycose solution in a two-lever, choice procedure. In the initial condition, the response requirement for each drink was set at five responses (variable-ratio 5); in subsequent conditions the variable-ratio values were increased to 7.5, 10, 15, and 30 responses. *Results:* In the initial condition, the rats drank twice as much Polycose as alcohol. However, with increases in the variable-ratio requirements, Polycose consumption systematically decreased, whereas sweetened alcohol consumption remained at its baseline level or above in all but the variable-ratio 30 condition. *Conclusions:* Rats defended baseline alcohol consumption but not baseline food consumption. As alcohol and food consumption can be dissociated in humans, research on the mechanisms that mediate alcohol regulated preference in rats may shed light on the mechanisms that control human alcohol consumption.

Key words Alcohol · Self-administration · Animal model · Behavioral economics · Rat

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Introduction

Since alcohol is a rich source of calories, an essential control condition for studies on preference for alcohol is access to a non-alcoholic, caloric substance. However, in current widely-used animal procedures, the introduction of palatable foods markedly reduced alcohol consumption, even when the foods were relatively poor sources of calories. A relevant example is a study in which selectively bred, alcohol-preferring (P) rats were trained to drink alcohol with Samson's sucrose fading procedure (Schwarz-Stevens et al. 1991). The P rats drank approximately 1 g/kg alcohol in 30-min sessions when water was the concurrent, alternative reinforcer. However, when a 5% sucrose solution was the concurrent reinforcer, alcohol consumption decreased by about 50%, and at 0.5 mg/kg, it is likely that the blood alcohol levels were rather low (Wallgren and Barry 1970).

In contrast to these results, in experiments in which alcohol was sweetened with sucrose or saccharin, the rats defended baseline levels of alcohol consumption despite access to 10% sucrose solutions (e.g. Petry and Heyman 1993; Heyman 1996), pre-session meals of chow and sucrose, and increases in body weight that markedly reduced within-session sucrose consumption (Heyman 1993). That is, manipulations that systematically altered food consumption produced little or no change in alcohol consumption. Pharmacological treatments also produced selective effects in the sweetened alcohol procedure. Ro15-4513, a benzodiazepine inverse agonist, and daidzin, an isoflavone, reduced sweetened

alcohol consumption at doses that did not decrease sucrose or Polycose intake (Petry 1995; Heyman et al. 1996). The experiment described in this report provides a more rigorous test of the dissociation between alcohol and food consumption in rats.

In the earlier experiments, alcohol was sweetened with sucrose or saccharin, and in the studies that included an isocaloric alternative (Heyman et al. 1996; Heyman 1997), the rats earned a drink by responding on a time-based ("variable-interval") schedule. In the current experiment, the alternative drinks were isocaloric, but they were dependent on a response-based schedule. This has several advantages over the earlier studies: (1) it puts more pressure on alcohol consumption because the rats will have to forgo a highly preferred food (Polycose) in order to preserve baseline alcohol levels; (2) it allows the rats to control precisely alcohol intake levels, which was not possible with interval schedules; and (3) it leads to an economic analysis of the results that was not as appropriate in the earlier experiments.

The economic analysis is based on the similarities between prices and response requirements. A response requirement, like a price, establishes a rate of exchange between scarce commodities (e.g. behavior and reinforcers). Thus, we can take advantage of well-established economic principles in describing how changes in response requirements affect consumption of Polycose and alcohol.

The key idea in the economic analysis of consumption, and the one that we exploit, is that the degree to which a price change influences the consumption of a particular item depends on the availability of close substitutes. What is meant by the term "substitute" can be illustrated by comparing a particular and a general consumption item, for instance, peas and vegetables. The particular one necessarily has more substitutes than the general one (which is a collection of particular ones). Thus, the consumption of peas should be more price sensitive than the consumption of vegetables. Econometric research shows this to be the case (see, e.g. Houthakker and Taylor 1970; Nicholson 1985; Frank 1991). Following the practice in economics, we will refer to the relationship between changes in variable-ratio values (price) and changes in consumption as "price elasticity of demand". For instance, if the relative change in alcohol and/or Polycose consumption is less than the relative increase in response requirements, demand for these substances is "inelastic", and if the relative change in consumption is greater than the relative change in response requirements, demand is "elastic". Thus, the experiment in this report will test whether demand for alcohol is more or less elastic than is demand for a preferred food.

There were also two control experiments. At baseline, response rates maintained by Polycose were about twice as high as response rates maintained by saccharin-sweetened alcohol. To check if the initial differences in responding and consumption influenced the results (e.g. Dews and Wenger 1977), the procedure used in the alcohol study was repeated with two non-alcoholic reinforcers (sucrose and saccharin-sweetened Polycose) that maintained markedly different initial response rates (experiment 2). There was also a decrease in food intake over the course of the alcohol study. To check if this influenced the results, the relationship between post-session meal size and alcohol consumption was evaluated (experiment 3).

Materials and methods

Subjects

Male Wistar rats served as subjects. At the start of training, they were approximately 50 days old and weighed on average 224 g. In the primary, alcohol versus Polycose preference experiment, there were seven subjects. Each of the two control studies used eight subjects.

Apparatus

The experiments were conducted in eight standard operant chambers (Med Associates: 28 cm, 20.5 cm, 26 cm). Two levers (5 cm wide) were inserted into the front wall, 7 cm above the floor, and 1 cm from each side. The levers were operated with a force of about 0.25 N. Just below each lever (2 cm) was an opening into which a 0.1 ml dipper could be raised. The dippers, when not raised, sat in a trough that held the solutions. Experimental events were arranged and recorded with an IBM compatible personal computer that used MED-PC software (Tatham and Zurn 1988).

Experiment 1: effect of response requirement increases on alcohol and food consumption

Prior to the experimental conditions, the rats were induced to drink alcohol. The goal was to produce a large amount of drinking in a 45-min period. In the initial training condition, one dipper provided water and the other dipper provided a mixture of 2.5% alcohol plus 10% sucrose. Each dipper was operated according to a variable-ratio 5 schedule. In subsequent training conditions, the amount of alcohol was increased in 2.5 and 5% steps to 20% (v/v). Each concentration was kept in effect until response rates were stable (about five to ten sessions). The stability criterion was the absence of an increasing or decreasing trend in alcohol consumption for three consecutive sessions. Following stability at 20%, the alcohol concentration was brought back down to 10%. During this phase of training, median alcohol consumption varied from 2.50 to 4.75 g/kg per session.

In the next phase of training, the isocaloric conditions were established. First, sucrose was gradually removed (from the alcohol solution) and replaced by 0.25% saccharin. Once stable consumption levels were obtained (see Table 1), an 1.25% Polycose solution was substituted for water in the second trough. Over the course of 24 sessions, the concentration was increased to a target

Table 1 A summary of alcohol consumption amounts and the duration of each condition

Condition	Number of sessions	Alcohol: g/kg per session
Variable-ratio 5	8	2.5
Variable-ratio 7.5	6	3.1
Variable-ratio 10	7	2.9
Variable-ratio 15	6	2.4
Variable-ratio 30	12	1.8
Variable-ratio 5	5	3.1

of 14.8%. At this concentration, both solutions provided 0.56 kcal/ml.

Thus, in the final training condition, referred to in this paper as "baseline", one dipper served 10% alcohol plus 0.25% saccharin, and the second dipper served an isocaloric solution of 14.8% Polycose.

Body weight and feeding regime

Training lasted 108 sessions. Over this period, the rats increased in body weight, with an average increase in weight of 160 g. For the remainder of the experiment, body weight was held constant. The average was 385 g, with a range of 335–430 g. Thirty to 60 min after each session, the rats were given 12 g of chow in their home cage. In the experimental session they drank approximately 21–43 ml of Polycose and alcohol, depending on the ratio schedule requirement (see below). Across the course of the experiment, daily caloric intake was approximately 70 kcal.

Increasing the response requirements for alcohol and Polycose

Throughout training, and in the initial experimental session, a variable-ratio 5 schedule was in effect at each dipper. In subsequent experimental conditions, the response requirements were increased. The average variable-ratio values, in order and including the initial condition, were 5, 7.5, 10, 15, and 30 responses. After the variable-ratio 30 condition, the initial variable-ratio 5 condition was re-instated. Each condition was in effect until overall response proportions were not strictly increasing or decreasing over the last three sessions and until at least five sessions had elapsed. Sessions lasted 45 min. New alcohol solutions were mixed daily and kept in sealed flasks until the start of the experimental session.

Nominal and actual alcohol consumption levels

As in earlier studies, we checked the volume of the liquid in the trough to insure that actual consumption levels were approximated by those based on the number of dipper operations. The difference between the obtained and nominal volumes varied from an average of 9–13% across five different randomly selected sessions, with the predicted levels typically being smaller. This implies that some of the solution spilled during the course of the daily session.

Blood alcohol readings also provide proof that the rats actually ingested the alcohol. In an experiment in which alcohol consumption level was manipulated over a range of 0.25–4.0 g/kg, blood alcohol level was a linear function of nominal alcohol consumption (Heyman 1995), thereby indicating an orderly relationship between the available and actual consumption levels. In an experiment in which the rats were free to drink alcohol over a 30-min period, blood alcohol levels averaged 139 mg/dl (Heyman et al. 1996).

Experiment 2: control for baseline response and consumption rates

At baseline, the rats preferred Polycose to alcohol. Consequently we tested whether differences in the initial response and consumption levels could have influenced the results. The same apparatus and variable-ratio schedules were used. However, one dipper provided a 10% sucrose solution and the other provided an isocaloric 10.4% Polycose solution. The initial response rate differences approximated those in the alcohol study. Next, the variable-ratio requirements were increased, as in the alcohol study. As before, the average ratio values were 5, 7.5, 10, 15, and 30 responses. Each condition was in effect for at least five sessions and until response proportions appeared stable. This typically took ten sessions, and the range was 5–21 sessions.

Experiment 3: differences in food intake

Polycose consumption decreased during the course of the alcohol experiment. Consequently, we tested whether changes in food intake could have influenced the results. One dipper provided 10% alcohol plus 0.25% saccharin, and the other dipper provided 14.8% Polycose, as in the primary experiment. The variable-ratio value was five responses for both drinks. Food intake was manipulated by varying the size of post-session chow servings. In the alcohol-Polycose experiment, the post-session meal was 12 g chow. In this experiment, meal sizes were 4, 12, 16, 20, and 24 g. The order was random, and the 4 and 12 g meals were presented two and three times, respectively. The range of meal sizes (one to six) is identical to the nominal range of reinforcement rates in the previous experiment (variable-ratio 5 to variable-ratio 30). Each condition was in effect for at least five sessions and until response proportions appeared stable. This typically took ten sessions.

Dependent measures and statistics

The primary dependent measure was the relationship between change in consumption and change in response requirements. When the percentage change in consumption is proportional to the percentage change in response requirement, a fitted line is linear in logarithmic coordinates. Consequently, as in economics, the graphs are presented in logarithmic coordinates. Within-subject ANOVA tests were used to evaluate the probability that changes in consumption and response rates differed from baseline levels. In addition, we used contrast analysis (Rosenthal and Rosnow 1988) to test for linear and higher-order trends in the data.

Results

Increases in the schedule requirements systematically decreased Polycose consumption [$F(4,24)=39.8$, $P<0.001$]. Contrast tests showed a significant linear component [$F(1,6)=95.6$, $P<0.001$] and a significant cubic component [$F(1,6)=14.6$, $P<0.01$], which is apparent in arithmetic coordinates but not the logarithmic ones used for Fig. 1. As noted in the Materials and methods section, a linear relationship in logarithmic units implies a proportionality between relative changes in the variables. Thus, the graph shows that the relative decrease in Polycose consumption was proportional to the relative increase in schedule values. For example, Polycose consumption decreased about 42% for each doubling of the schedule values (compare the results for variable-ratio 5 to 10 and for variable-ratio 15–30). Overall, there was more than a 70% decrease in Polycose consumption (from 24.1 to 6.7 ml).

Alcohol consumption showed a different pattern in relation to the increase in response requirements. In the variable-ratio 7.5 and 10 conditions, six of the seven rats drank more alcohol than they did in baseline, and the increase in the 7.5 condition was significant at the 0.05 level [$F(1,6)=6.65$, $P<0.05$]. In the variable-ratio 30 condition, six of seven rats drank less than in baseline [$F(1,6)=5.33$, $P<0.06$]. However, the decrease was small relative to the decreases in Polycose consumption. Consequently, in the variable-ratio 30 condition, the rats drank more alcohol than Polycose. Overall, there was no more than a 20% decrease in alcohol consumption, and decreases were restricted to the condition with the largest

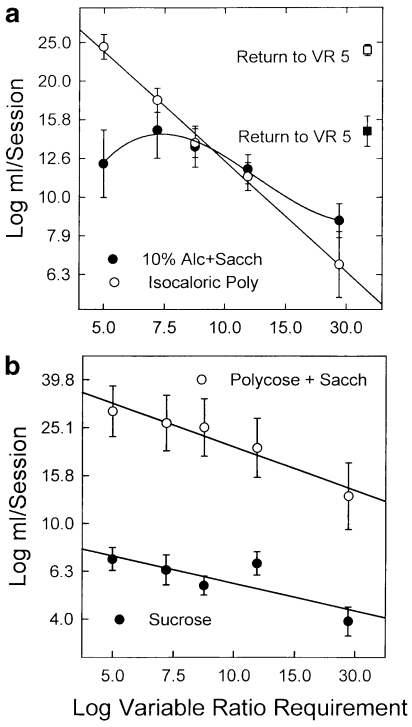

Fig. 1 **a** Polycose (○) and sweetened alcohol (●) consumption as a function of the response requirement (variable-ratio value). The rats defended alcohol consumption but not Polycose consumption. **b** Changes in sucrose (●) and sweetened Polycose (○) consumption in a control condition. Demand for sweetened alcohol was greater than was demand for sucrose, Polycose, and saccharin flavored Polycose. The data points were calculated from the last three sessions of each condition, and the error bars indicate SEMs. *Squares* in **a** represent return to variable-ratio 5 (■ sucrose, □ sweetened alcohol

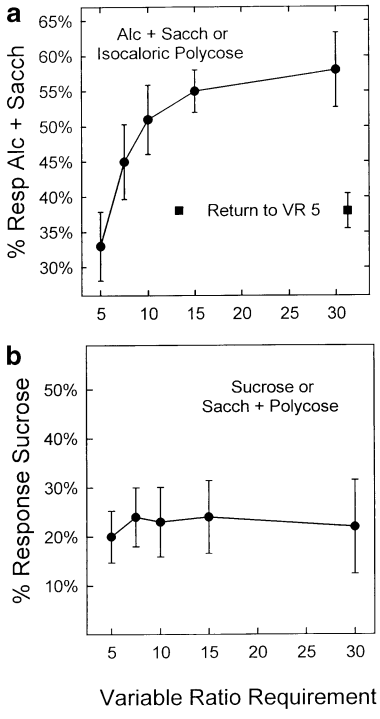

Fig. 2a, b Preference (relative response rate) as a function of variable-ratio values. **a** Increases in the response requirements increased preference for alcohol. *Squares* indicate the return to variable-ratio 5. **b** Increases in response requirements had little influence on preference when both reinforcers were food (sucrose and Polycose plus saccharin)

response requirement. In relative terms, it took a 500% increase in schedule values to produce a 20% decrease in consumption. In contrast, a 50% increase in schedule values produced a 27% decrease in Polycose consumption. Table 1 lists the alcohol levels and the number of sessions in each condition.

The detached data points on the right side of the graph indicate consumption levels when baseline conditions were re-instated. Polycose consumption returned to close to its original values (24.1 and 24.6 ml/session in baseline 1 and baseline 2, respectively). Alcohol consumption returned to its level in the variable-ratio 7.5 condition (14.8 ml/session). This was equal to the highest rate of alcohol consumption, but was not different at the 0.05 level from baseline 1, as not all subjects showed increases [$t(6)=1.86$ $P>0.11$].

Figure 1b shows the relationship between consumption and response requirements in the response rate control study (experiment 2: sucrose versus saccharin plus Polycose). In the initial condition, variable-ratio 5, there was an approximately 4-fold difference in response (and consumption) rates for the two food reinforcers. However, increases in response requirements produced approximately the same pattern of change in consumption for both sucrose and Polycose. For example, in the variable-ratio 7.5 condition, sucrose and Polycose intake decreased 10 and 11%, respectively, and in the variable-ratio 30 condition, the decreases were 45% and 56%. Although, sucrose consumption tended to decrease more, the differences were not consistent enough to reach significance at the 0.05 level. A slope test (Draper and Smith 1981) yielded a probability of not less than 0.30 for the null hypothesis [$t(6)=1.25$].

Figure 2 shows relative response frequency (or preference) as a function of response requirements in the alcohol study and the response-rate control study. Increases in response requirements increased the relative frequency of responding at the alcohol lever [$F(4,24)=7.7$, $P<0.001$]. For example, as the response requirement increased from 5 to 30 responses, the relative frequency of responding at the alcohol lever increased from 34 to 56%. The detached point on the right side of the graph shows relative response frequency after baseline conditions were re-established. Relative response frequencies for alcohol moved back to about their initial baseline level [$t(6)=1.08$, $P>0.32$].

Figure 2b shows the relative frequency of responding at the lever that operated the sucrose dipper in the sucrose versus Polycose, response-rate control study. Changes in the variable-ratio values had little apparent influence on relative response frequency in this experiment. The range of variation was no more than 4%, and

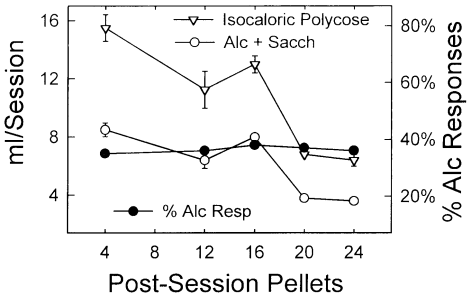

Fig. 3 The minute-by-minute temporal pattern of responding for alcohol and food at three different response requirements. On the *x*-axis is time since the start of the session. On the *y*-axis is response rate, averaged across the seven rats. The *bars* show SEs. Data are from one of the last three sessions of each condition and show the group average response rates. Note that the pattern of responding differed as a function of whether the reinforcer was alcohol or Polycose. ▽ Isocaloric Polycose, ○ sweetened alcohol, ● % alcohol responses

the changes were not systematically related to response requirements.

Figure 3 shows the results for the experiment that examined the relationship between feeding-conditions and preference for alcohol. Increases in the magnitude of post-session meals decreased sweetened alcohol and Polycose consumption by about the same degree. At the largest meal size (24 pellets or approximately 72 g), alcohol consumption decreased by 58% and Polycose consumption decreased by 59%. As the changes were so similar, preference remained approximately constant, varying from a low of 35% to a high of 38%. Body weight, not shown, varied between 395 and 484 g.

Figure 4 shows the temporal pattern of responding in the alcohol-Polycose experiment under three different response requirements. The temporal pattern of responding for food and alcohol differed. In the variable-ratio 5 condition, responding maintained by alcohol began to decline after about the first 6 min of the session (or about 3 ml of 10% alcohol). In contrast, responding maintained by Polycose did not start to decline (steadily) until the middle of the session (or after about 12 ml of 14.8% Polycose). Second, under each of the different variable-ratio schedules, Polycose reinforced responding followed an upward trajectory during the initial minutes of the session. This was most pronounced in the variable-ratio 30 condition, but is apparent in the variable-ratio 5 condition as well. In contrast, alcohol-reinforced responding remained more or less at a steady level and then declined as a function of alcohol consumption.

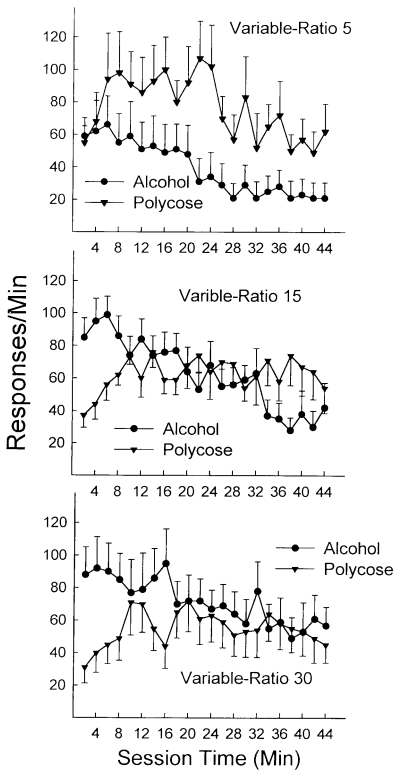

Fig. 4 The effect of changes in post-session meal size on consumption and relative response rates. Larger feedings decreased the absolute rates of responding and consumption, but had little effect on preference. ● Alcohol, ▼ Polycose

Discussion

There was a clear dissociation between Polycose and sweetened alcohol consumption. For a given variable-ratio value, the temporal pattern of food and alcohol intake differed, and when schedule values were increased, the rats defended alcohol consumption but not Polycose consumption. In economic terms, demand for alcohol and for Polycose was inelastic, but demand for alcohol was considerably more inelastic. The results from earlier experiments suggest that the difference in demand elasticity depended on alcohol's pharmacological effects. However, we will consider first whether the results may be explained better by differences in taste, initial response rates, or changes in food intake.

If taste differences influenced demand elasticity in the alcohol experiment, they should also influence demand elasticity for other substances. The following experiments test this prediction.

In an earlier study, quinine was used to determine whether taste influenced demand elasticity in rats (Heyman 1997). One dipper served 10% sucrose, and the other served 10% sucrose adulterated with quinine. At baseline, the rats preferred the unadulterated sucrose by about a five to one margin. However, when the schedule requirements for unadulterated sucrose were increased, the rats simply switched to quinine flavored sucrose. That is, flavor did not influence whether one sucrose substance would substitute for the other, even though the rats highly favored sucrose without quinine. Put another way, although the rats favored unadulterated sucrose, they did not work harder to obtain it when its schedule requirement was increased. These results suggest that taste influences initial consumption levels but not the degree to which the initial consumption levels are defend-

ed. The results from experiment 2 of this report lead to the same conclusion. The rats preferred saccharin-flavored Polycose to sucrose by more than a three to one margin. Yet when the response requirements were increased, consumption of both substances decreased by about the same degree. Note also that in this experiment, the rats did not defend saccharin. Similarly, in an earlier study (Heyman 1997), rats did not defend consumption of saccharin flavored water when the alternative was a 1.5% sucrose solution.

In each test, taste failed to influence demand elasticity. This does not mean that taste did not influence consumption, for it surely must. Rather, it means that when initial consumption levels were challenged, taste did not motivate the rats to overcome the challenge. These findings suggest that the rats did not defend alcohol in order to preserve baseline saccharin levels.

Experiment 2 provided a control for response rate differences. Figures 1 and 2 show that response rate differences did not lead to differences in demand elasticity. Experiment 3 provided a control for the decrease in caloric intake that accompanied the increase in schedule requirements in the alcohol study. Figure 3 shows that increases in overall calorie intake decreased the absolute levels of responding, but not preference. Thus, neither response rate differences nor changes in caloric intake explain the differences in demand elasticity.

According to economic research and theory, the most likely explanation for differences in demand is the availability of substitutes. If this prediction holds for the present experiment, then sweetened alcohol had fewer substitutes than Polycose. Two sets of findings support the economic approach.

First, earlier research (described in the Introduction) suggests that sweetened alcohol has pharmacologically based rewarding effects that distinguish it from both sucrose and Polycose (Petry 1995; Heyman et al. 1996). Second, home cage chow, provided at the end of the session, was more likely to substitute for Polycose than for alcohol. For instance, in an earlier study, pre-session meals of chow reduced sucrose consumption but not sweetened alcohol consumption (Heyman 1995). Thus, economic theory and experimental results converge on a common conclusion: demand for sweetened alcohol was more inelastic because of its unique pharmacological properties and the availability of post-session food.

Differences in the demand for alcohol and for Polycose were not only a matter of degree. In the variable-ratio 7.5 and 10 conditions, alcohol consumption increased, whereas Polycose consumption decreased. The increase in consumption is a surprising result. According to the “law of demand”, increases in price should decrease consumption. Indeed, all choice theories include the common sense idea that as cost increases preference decreases, all else being equal. However, the increase in alcohol consumption can be explained.

Economic theory provides a principled argument for an exception to the law of demand. An increase in price necessarily reduces real income. If the decrease is quite large, then preferences may shift to goods that are more essential (Frank 1991; Salvatore 1994). Thus, if the price of an essential good increases, the income effect can offset the increase in price and demand for the good will increase. Although it is not clear whether these dynamics ever apply in real markets (where the income effect of a price increase is almost always quite small), they may apply to this experiment because the income effect was potentially quite large. For instance, the smallest increase in variable-ratio value decreased the value of a response by 50% (as measured by its potential to secure either a drink of alcohol or Polycose). Note also that this argument assumes that sweetened alcohol was more “essential” to the rats than was Polycose.

Alternatively, tolerance or other factors may have led the rats to drink more alcohol. In support of this idea, alcohol consumption returned to the elevated level rather than to the original baseline level when the baseline schedule was reinstated at the end of the experiment (see detached points in Fig. 1). Also note that these two accounts are not mutually exclusive. The dynamics of the income effect could have driven alcohol consumption up, and, then, when the response requirements were relaxed, consumption returned to the new, preferred level, due, perhaps, to tolerance and/or other factors.

The results presented here are consistent with earlier studies using sweetened alcohol (e.g. Files et al 1995), but differ from those studies that use unsweetened alcohol. For instance, as noted in the Introduction to this paper rats that had been selectively bred to consume alcohol (the P rat) did not defend a 10% alcohol-water mixture when the alternative reinforcer was sucrose. In the P rat study, a competing 1% sucrose solution reduced alcohol consumption by about 25% and a competing 5% sucrose solution reduced alcohol consumption by about 50% (Schwarz-Stevens et al. 1991). This contrast, along with the various control experiments, suggests the following account of the role of the sweetener in rat alcohol studies.

Saccharin greatly increases the rate and amount of alcohol consumption. For example, the rats in this study drank about two to four times the amount of alcohol that selectively bred, alcohol preferring (P) rats drank in a similar procedure (e.g. Schwarz-Stevens et al. 1991). When alcohol is consumed rapidly, say more than 2.5 g/kg per 45 min, its rewarding effects are markedly enhanced and are distinct from those of foods such as chow, sucrose, and Polycose. For instance, pre-session meals of chow and sucrose and increases in body weight that reduced food consumption had little influence on sweetened alcohol consumption. Similarly, increases in response requirements reduced food consumption but not alcohol consumption (Heyman and Oldfather 1992; Files et al. 1995; experiment 1 of this report). In contrast, the rats did not defend solutions of saccharin and water (Heyman 1997) or solutions of saccharin and Polycose (experiment 2). A simple hypothesis summarizes these diverse findings: the rats defended alcohol consumption because of the strength and uniqueness of alcohol’s re-

warding effects; strength and uniqueness were in part a function of the rate and amount of alcohol consumption; saccharin enhanced the rate and amount of alcohol consumption.

We have successfully developed an animal procedure in which the rewarding effects of alcohol can be dissociated from those of highly preferred foods, and in which rats defended baseline levels of alcohol consumption. These results may have relevance for the understanding of human drinking. Human alcohol consumption is readily dissociable from food consumption (which is not to say that alcohol's calories are without effect), and problem drinkers can be said to defend a preferred level of alcohol consumption in that their drinking persists despite aversive consequences. Thus, research on the biological mechanisms that mediate inelastic demand for sweetened alcohol in rats hold promise for the understanding of the mechanisms that regulate human alcohol consumption, especially among problem drinkers.

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