pressure operates on a variety of animals, of course, but we may expect adaptations to it to be most evident among omnivorous feeders. Alcock (1971) has compared learned food aversions in black-capped chickadees, which are relatively wide-ranging eaters, and white-crowned sparrows, which are more conservative eaters. He found that the chickadees developed more generalized and more persistent aversions to noxious mealworms than did the sparrows. We would generalize these findings to predict that learned food aversions would be quite difficult to demonstrate in highly specialized feeders.

The present results indicate that the environmental cue which is most instrumental for the rat in producing aversion for illness-producing foods appears to be the flavor of the food, with visual and olfactory cues playing much less of a role. However, it would be wrong to conclude that the rat cannot acquire a food aversion based upon the sight or smell of a substance. For one thing, there is no reason to suppose that the different test procedures used here for the different sense modalities had the same sensitivity, so that we could not have gotten location- or olfactory-based aversion by using other procedures. For another thing, food aversions cued by other sense modalities have been reported in the rat (Garcia et al, 1961; Lovett et al, 1968). But when we turn to dimensions other than taste or to behaviors other than ingestion (Garcia, Kovner, & Green, 1970), we find much less impressive and less rapid learning. What should be concluded, then, is that the rat has a remarkable ability to learn a particular kind of highly specific association, namely, the avoidance of a taste that has preceded illness.

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Extinction in a straight alley as a function of varied quality and quantity of reward sequence

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Six groups of albino rats were extinguished in a straight alley after receiving two daily trials on one of the following varied quality and/or quantity of reward sequences: 1 regular pellet followed by 1 regular pellet, 1 regular pellet followed by 1 sucrose pellet, 1 sucrose pellet followed by 1 regular pellet, 1 regular pellet followed by 16 sucrose pellets, 1 sucrose pellet followed by 16 sucrose pellets, and 16 sucrose pellets followed by 1 sucrose pellet. Further evidence for an extension of the sequential hypothesis to include quality of reward was provided by showing that greater resistance to extinction results when a high-quality reward follows a low-quality reward than when the opposite sequence occurs. In addition, variations in both quantity and quality of reward produced more resistance to extinction than variations in quantity of reward alone.

In a varied magnitude-of-reward experiment, Leonard (1969) reported that Ss receiving two trials a day with a small reward on Trial 1 and a large reward on Trial 2 (SL) were more resistant to extinction than Ss receiving the opposite sequence (LS). Recently, Russin, Boyer, & Cross (1970) demonstrated that quality of reward operates similarly to quantity of reward in a two-trial sequence. While this study suggested that a "high-quality" reward following a "low-quality" reward¹ produced more resistance to extinction than a low-quality reward following a high-quality reward, a much stronger effect was observed by varying both quality and quantity of reward than quantity alone.

These results have been interpreted within a sequential framework (Capaldi, 1967) which states that different magnitudes of reward vary along a continuum, large reward to no reward, and that a small reward on Trial 1 produces a stimulus aftereffect which is very similar to the aftereffect of nonreward experienced in extinction. The Trial 2 reward conditions this aftereffect strongly or weakly depending upon its size.

Resistance to extinction can thus be increased by using a second reward greater in magnitude than the first reward. The present experiment represented an attempt to verify the Russin et al findings and to test more completely the effect of varied quality and combinations of varied quality and quantity of sequenced rewards upon extinction.

Six groups of rats were given two trials each day on one of the following reward sequences: Group R1-R1 received 1 regular pellet on the first daily trial, followed by 1 regular pellet on the second daily trial; Group R1-S1, a single regular pellet followed by a single sucrose pellet; Group S1-R1, 1 sucrose pellet followed by 1 regular pellet; Group R1-S16, a single regular pellet on Trial 1 followed by 16 sucrose pellets on Trial 2; Group S1-S16, a single sucrose pellet followed by 16 sucrose pellets; and Group S16-S1, 16 sucrose pellets on the first trial followed by 1 sucrose pellet on the second trial. The sequential hypothesis, in combination with the Russin et al findings, would allow the prediction that the rank ordering of groups from most resistant to least would be as follows: R1-S16, S1-S16,

R1-S1, R1-R1, S1-R1, and S16-S1. This prediction assumes that quality of reward operates similarly to magnitude of reward in determining the amount of habit strength that generalizes to the aftereffect of nonreward in extinction.

SUBJECTS AND APPARATUS

The Ss were 66 male albino rats purchased from Carworth, Portage, Michigan, and were approximately 80 days old on arrival. A straight-alley runway, 63 x 6 x 12 in., constructed of plywood and painted flat gray, served as the experimental apparatus. The floor of the startbox consisted of a pressure plate which, when depressed, activated a .10-sec timer. A second pressure plate was located immediately in front of a guillotine door which controlled access to the goalbox. Rewards consisted of .045-g sucrose and regular Noyes pellets.

PROCEDURE

Upon arrival at the laboratory, Ss were housed in pairs and given 20 days of habituation. They were maintained on Purina Lab Chow pellets, and water was available ad lib in the home cage. During this period each S was handled for approximately 2 min daily. One week before the beginning of training, all Ss were placed on a 23-h food-deprivation schedule, maintained throughout the experiment. During this time Ss also received two 10-min daily periods of unrewarded runway exploration. Two days prior to the first training day, the Ss were assigned randomly to the six groups described above, and each S was given six rewarded goal placements, three per day. Goal placements consisted of placing the S directly into the enclosed goalbox and allowing him to consume the food. Ss in Groups R1-R1, S1-R1, and R1-S1 were given a single regular .045-g Noyes pellet in order to insure that these Ss did not have experience with different magnitudes of reward. Ss in Groups R1-S16, S1-S16, and S16-S1 received four regular pellets per placement, following the procedure employed by Leonard (1969).

Following completion of goalbox placements, Ss were given two training trials per day for 10 days, according to their group designation as previously described. The Ss were run in squads of four Ss, where each S was run in rotation. This procedure produced an intertrial interval (ITI) of approximately 2-4 min.

Extinction was introduced the day following completion of acquisition, and all Ss were given 15 massed extinction trials, using the squad procedure. The ITI was approximately 2-4 min. On reinforced trials, each S was confined in the goalbox until he had finished eating the food. During

extinction trials, each S was confined in the goalbox for 30 sec. If a S failed to enter the goalbox within 2 min, it was gently pushed into the goalbox and given a score of 120 sec. Two Ss from the S1-S16 group and one from the R1-S1 group were discarded during the course of the experiment due to middle-ear infection.

RESULTS

Time scores were transformed into speeds, $1/\text{time (sec)} \times 100$, for statistical analysis. An analysis of variance performed on the last acquisition trial revealed no significant difference among groups [$F(5,58) = 1.48$, $p > .05$]. The running speeds in extinction were combined into three-trial blocks, and an analysis of variance was computed on these scores. The results of the analysis indicated that the effects due to reward conditions during acquisition [$F(5,57) = 7.09$, $p < .001$], trials [$F(4,228) = 92.95$, $p < .001$], and the Reward Conditions by Trials interaction [$F(20,228) = 3.26$, $p < .001$] were all significant. Subsequent tests with the Duncan multiple range test indicated that the only significant ($\alpha = .05$) mean difference among the groups was between the two extreme scores, R1-S16 and S16-S1. Since the Russin et al study provided an a priori basis for making predictions about the order of the groups in terms of resistance to extinction, Page's (1963) rank test for ordered hypotheses was applied to the data. The results ($L = 422$, $p < .001$) confirmed the predicted rank ordering of the groups in extinction. Table 1 summarizes the main extinction data.

DISCUSSION

The ordering of the groups in extinction is generally consistent with the predictions from sequential theory. In this respect, these data are similar to those reported by Russin et al and provide further evidence for an extension of the sequential hypothesis to include quality of reward. It appears that high-quality rewards operate similarly to large magnitudes of reward, and low-quality rewards are comparable to small-quantity rewards. When varied-quality rewards are used, resistance to extinction depends on the order in which the rewards are

Table 1
Transformed Mean Speeds in Extinction for Six Varied Quality and Quantity of Reward Sequence Groups

Groups	Mean
R1-S16	65.43
S1-S16	53.84
R1-S1	42.65
R1-R1	35.60
S1-R1	41.46
S16-S1	25.38

given. Extinction is enhanced when a high-quality reward follows a low-quality reward, but is reduced if the opposite sequence occurs. More importantly, a comparison between sequences varying reward magnitude only (S1-S16) with those varying both quality and quantity (R1-S16) indicates that the addition of quality increases resistance to extinction, since the total amount of reward is the same for both conditions. Though the ordering of the groups in extinction is generally consistent with predictions from sequential theory, only the difference between R1-S16 and S16-S1 was significant. While the small differences between groups are partially inconsistent with the earlier study (Russin et al, 1970), the discrepancy might be due to the different types of low-quality rewards employed in the two studies. The present investigation used regular pellets, whereas the previous one utilized an alfalfa-base pellet during training. It might be speculated that an alfalfa reward provides a weaker stimulus aftereffect (than a regular reward), which is then conditioned more strongly by a higher quality and/or quantity Trial 2 reward. The small differences in extinction performance between groups might then be accounted for by differences in the two rewards.

It should be mentioned that Ss in Groups R1-R1, R1-S1, and S1-R1 received six one-pellet goalbox placements, while Ss in Groups R1-S16, S1-S16, and S16-S1 received six four-pellet placements prior to acquisition training. Reward magnitudes in goalbox placements have been ignored here and in previous studies (e.g., Leonard, 1969). It is possible that this experience might have a significant effect upon subsequent sequential training and should be systematically examined.

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NOTE

1. The matter of "high" and "low" quality of reward reduces, operationally, to S's preference. For example, Ss typically run faster to sucrose reward than to regular or alfalfa reward.