

## THE INFLUENCE OF GRADED REDUCTIONS IN REWARD AND PRIOR FRUSTRATING EVENTS UPON THE MAGNITUDE OF THE FRUSTRATION EFFECT<sup>1</sup>

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Interpretations of recent experiments by Amsel (1958a, 1958b) have attributed active, motivational effects to nonreward occurring in contexts where *S* has been led to expect reward. Since this conception of nonreward has been featured prominently in recent accounts of partial reinforcement and extinction phenomena (Amsel, 1958a; 1958b; Spence, 1960), it is important to determine some of the laws concerning motivational consequences of reduced reward. It is to this task that the present investigation is directed.

The standard procedure for studying motivational consequences of nonreward was introduced in an experiment by Amsel and Roussel (1952). Hungry rats were trained to run down a runway into a first goal box ( $G_1$ ) for food reward; after a suitable time, a door opened to a second runway, which the rat traversed to a second goal box ( $G_2$ ) and a second reward. After training on this two-link sequence, reward in  $G_1$  was omitted occasionally. On such occasions, response speed in the second runway was increased substantially. The increased vigor of the second response was attributed by Amsel and Roussel to frustration motivation evoked by nonreward in  $G_1$  after *S* had been led to expect reward there. This frustration effect (FE) has been observed in several subsequent experiments, and there is little doubt about its reliability. Moreover, in a well-controlled experiment by Wagner (1959), it was demonstrated that the performance difference following reward vs. nonreward in  $G_1$  was not due to a loss of hunger drive following the customary reward in  $G_1$ .

These previous studies have demonstrated FE when the reward in  $G_1$  was reduced to zero. The first question prompting the present experiment was whether the size of FE would be graded according to graded reductions in reward at  $G_1$ . To this end, rats were trained

with a large reward in  $G_1$ ; on test trials, one of several smaller rewards (including no reward) were provided in  $G_1$ , and FE following the test reward was measured by the increment in response speed in the second runway.

A second question of this experiment was whether two frustrating events occurring close together in time would summate in their effects upon performance. For these purposes, a third runway was added to the Amsel and Roussel apparatus and *Ss* were trained with reward in the three consecutive goal boxes. Tests involved various combinations of reduced rewards in  $G_1$  and in  $G_2$ . If the function relating FE in the third runway to reward in  $G_2$  were shifted up and down according to the immediately prior reward in  $G_1$ , then such evidence would imply perseveration and summation of the prior frustration from  $G_1$  with the frustration evoked by the reduced reward in  $G_2$ .

### EXPERIMENT 1

#### *Method*

*Subjects.* Ten male albino rats, approximately 100 days old, served as *Ss*. They were housed in individual living cages and maintained on ad lib. water. Each *S* received 12 gm. of Purina lab checkers following the daily experimental session; thus, *Ss* were approx. 23-hr.-deprived at the time of testing the next day.

*Apparatus.* Three enclosed wooden runways, 3 by 4 by 24 in. long with wire-mesh tops, were painted flat black and attached between one start box, two intermediate goal boxes, and one terminal goal box. The start box and goal boxes were of identical construction, 10 by 10 by 4 in. high, painted flat black. The three runways were arranged in a U pattern with the start box and three goal boxes comprising the four corners. The first and second goal boxes served also as start boxes for the second and third runways, respectively. Bottle caps to hold the food pellets were secured to the floor in the back corner of each goal box. Guillotine doors could be lowered to block the entrances and exits of the goal boxes. Running time in the middle 18 in. of each runway was recorded to .01 sec. with a Standard Electric clock operated by photoelectric relays.

*Procedure.* Initial training consisted of 33 days at six trials per day with 8 Noyes food pellets (45 mgm. each) in  $G_1$  and  $G_2$  and 1 pellet in  $G_3$ , each *S* receiving

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single trials in rotation with the other *Ss*. The test series began on Day 34 and consisted of presenting novel pairs of  $G_1$  and  $G_2$  rewards, the reward at  $G_3$  remaining fixed at 1 pellet throughout. Tests may be identified by two numbers; thus, 4-1 will refer to a test with 4 pellets in  $G_1$  and 1 pellet in  $G_2$ . During the basic test series, 15 combinations of reward were presented corresponding to all possible pairs (except the regular 8-8 pair) formed by 8, 4, 1, and 0 pellets at  $G_1$  and at  $G_2$ . Additional tests were given with the selected pairs 6-8, 12-0, 16-0, the latter two pairs consisting of  $G_1$  rewards larger than the customary 8 pellets. There were 36 test days; the 6-8 tests did not start until Test Day 12; the 12-0 and 16-0 tests did not start until Test Day 24. There were six trials per day: a random three of these employed test pairs of reward, and the other three were regular 8-8 trials. Each test pair of rewards occurred six times over the entire series, once in each of the six possible trial positions within the day. All *Ss* received the same sequence of tests. At  $G_1$  and  $G_2$ , the exit door to the next runway was opened as soon as *S* finished eating and oriented to the exit door. These times were necessarily correlated with the amount of reward given on test trials.

*Data analysis.* Running times were converted to speed scores for analyses. The FE score assigned to an *S* on a given test trial was the difference between its response speed on that trial and its average speed over the three regular 8-8 trials of that day. Calculations of daily means and FE scores were made separately for the second and third runways ( $R_2$  and  $R_3$ ). During the prolonged test series, there was a mild decline (approximately 8%) in regular and test-trial speeds in all three runways; consequently, absolute difference (FE) scores were slightly smaller on later tests. The fact that  $R_3$  speeds declined somewhat even though  $G_3$  reward was constant suggests that extraexperimental factors (e.g., seasonal increase in temperature and humidity) were responsible.

## Results

*Frustration related to reduced reward.* The influence of reduced reward upon subsequent performance is shown in Figure 1, which presents mean FE scores for the second runway. The point on the graph at 8 pellets is forced to be zero since that served as the baseline for calculating difference scores. The average  $R_2$  speed following 8 pellets in  $G_1$  was 130, so the increase of 34 speed points at 0 pellets represents a 26% increase. In the right half of Figure 1, the increase in  $R_2$  speed is positively related to the reduction in reward below the customary 8 pellets. The function is representative of the performance of individual *Ss*; the mean speeds of all 10 *Ss* on the tests were ranked in the order 0, 1, 4, 6, 8. The probability of this happening by chance is 1 in 5! raised to the tenth power, which seems suitably small. The consistent rankings also imply that each

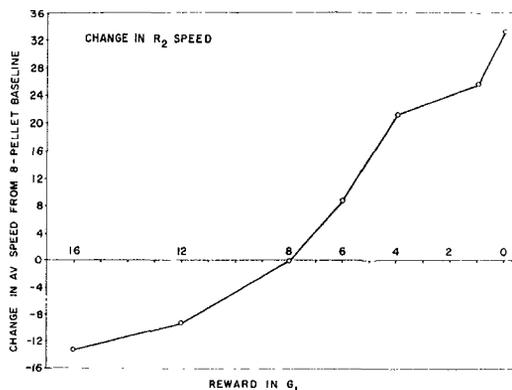


FIG. 1. Average change in  $R_2$  speed following test rewards above and below the regular 8-pellet reward. (The points at 0, 1, and 4 pellets were based on 24 observations per rat; the points at 6, 12, and 16 pellets were based on 6 observations per rat.)

point on the upper half of the function is significantly different from every other point. Turning to the left half of Figure 1, one sees that 12 and 16 pellets in  $G_1$  depressed  $R_2$  speed below the 8-pellet baseline. Both points are significantly below the baseline ( $p < .01$ ) but do not differ reliably from each other.

Because each test reward occurred equally often at each trial position within the day, the FE scores may be examined for within-day effects. If, for example, one were to explain FE as due to a loss of drive on rewarded trials, then smaller FE scores would be expected for tests given later in the day because of cumulative satiation from prior rewards. The data fail to support this expectation: average FE was largest on Trials 2 and 3 of the day and was nearly identical on Trials 1, 4, 5, and 6. The within-day differences were small relative to average FE and the same within-day pattern of speeds was evident on the regular 8-8 trials.

*Summation of frustration effects.* The principal results on summation are shown in Figure 2, which plots average FE in the third runway against reward in  $G_2$ , with the immediately prior reward in  $G_1$  serving as the parameter of each curve. The FE increases as  $G_2$  reward is reduced below the customary 8 pellets ( $p < .0001$ ). The prior reward in  $G_1$  has a smaller but consistent influence on FE in the third runway ( $F = 9.35$ ;  $df = 3,27$ ;  $p < .01$ ). To show clearly this carry-over effect from  $G_1$  reward, Figure 3 presents a curve relating the

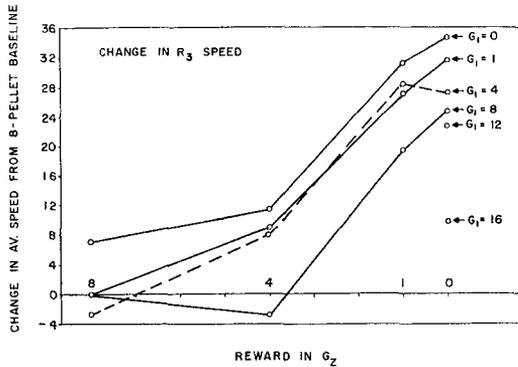


Fig. 2. Average change in  $R_3$  speed following reduced test rewards in  $G_2$ . (The immediately prior reward in  $G_1$  is the parameter of each of the curves. Each point on the graph is based on 6 observations per rat.)

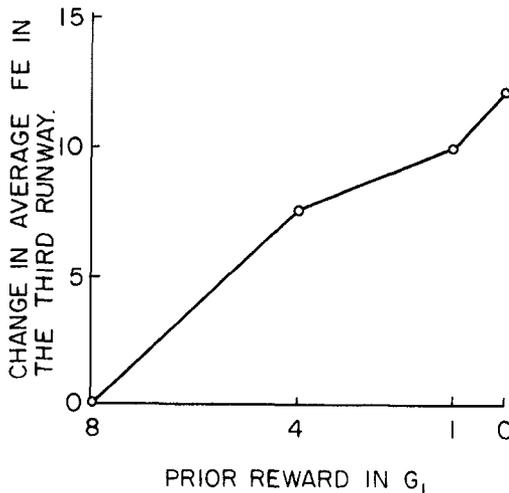


Fig. 3. The influence of prior  $G_1$  reward upon the average FE in the third runway. (Average FE in the third runway following 8 pellets in  $G_1$  was the baseline for calculating the difference scores.)

increase in the average FE scores in the third runway to the prior reward in  $G_1$ . The average FE in  $R_3$  following 8 pellets in  $G_1$  was the baseline for calculating these change scores. The influence of  $G_1$  reward upon FE in the third runway appears to be an "additive" effect; that is, the interaction between  $G_1$  reward and  $G_2$  reward in determining FE in the third runway was insignificant. It may be noted also that the single points in Figure 2 (at extreme right) for  $G_1$  rewards of 12 and 16 pellets are what would be expected from their effects on speed in the second runway.

In conclusion, the experiment provides some evidence that FE is a graded function of changes in reward magnitude on test trials, and that frustration from the first goal box carries over and influences performance in  $R_3$ . To establish further the reliability of the first finding, a replication experiment was conducted using a smaller reward (4 pellets) during training. In the replication experiment, only the first two runways were used, and so no evidence was collected relevant to the issue of summation of frustration.

## EXPERIMENT 2

### Method

**Subjects.** Sixteen albino rats, eight males and eight females approximately 90 days old, served as *Ss*. They were housed in individual living cages with free access to water and maintained on 12 gm. of Purina lab checkers daily.

**Procedure.** The apparatus and procedure were identical to those in Experiment 1 with the following exceptions: (a) the third runway was not used, the trial terminating after *S* was rewarded in the second goal box, and (b) the training rewards were 4 Noyes pellets in  $G_1$  and in  $G_2$ . After 24 days of training at six trials per day with the 4-4 reward combination, a test series was given in which rewards in  $G_1$  were varied from 4 to 3, 2, 1, or 0 pellets, the  $G_2$  reward remaining fixed at 4 pellets. There were 8 test days, each consisting of three randomly placed regular trials (4 pellets) and three trials with different test rewards. Each test reward occurred six times over the series, once in each possible trial position within the day. The FE scores for the second runway were calculated as in Experiment 1.

### Results

The results are presented in Figure 4, which relates average FE to the reward in  $G_1$  on test trials. Again the function is representative of the performance of individual animals; 12 of the 16 *Ss* ranked the rewards in the order 0, 1, 2, 3, 4 on the basis of their average  $R_2$  speeds. The other 4 *Ss* had one reversal each in their rankings of the test rewards. The difference between average FE at the various test rewards is highly significant. About 99.9% of the variance between treatments can be attributed to a linear trend between FE and test reward; the *F* value for the linear component of variance between test rewards was 130 ( $df = 1,45$ ). Thus, the substance of the first finding in Experiment 1 was replicated at a smaller value of training reward.

Analysis of speeds within the six trials of

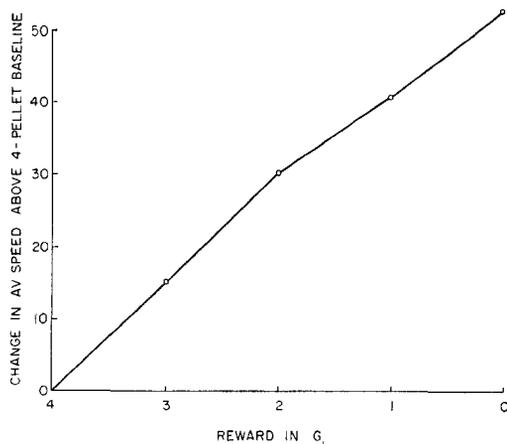


FIG. 4. Average change in  $R_2$  speed following test rewards of 3, 2, 1, or 0 pellets after training with 4 pellets' reward. (Each point is based on 6 observations per rat.)

the day revealed the same small effects as in Experiment 1 with slightly faster speeds on Trials 2 and 3 of the day. Rigorous comparisons between the two experiments are precluded because of changes in  $G_2$  reward and uncontrollable seasonal variations in temperature and humidity of the laboratory.

#### DISCUSSION

These experiments were designed in terms of Amsel's theory of frustration motivation, and the results may be interpreted as showing, first, that the amount of frustration is about proportional to the reduction in reward and, secondly, that frustrating events occurring close together in time summate in their motivational effects upon performance. In Amsel's discussion, frustration is considered to result from nonreward only after a stable anticipatory goal response ( $r_\theta$ ) has been conditioned to stimuli of the instrumental sequence preceding reward. In terms of this mechanism the present results require some additions to Amsel's hypotheses. Specifically, it must be assumed that the  $r_\theta$ -amplitude that is learned is directly related to the amount of training reward and, secondly, that the frustration reaction is proportional to the discrepancy between the reduced reward and that reward appropriate to the ongoing  $r_\theta$ -amplitude. The frustration reaction to a given discrepancy in reward presumably follows something like a Weber function. This last assertion implies that

percentage reduction in reward would be an appropriate index of the variable controlling frustration reactions. Results from our two experiments are consistent with this view.

An alternative account of these data is provided by the demotivation hypothesis (Seward, Pereboom, Butler, & Jones, 1957); namely, the more food the animal eats in  $G_1$ , the poorer will be its subsequent performance because of the resulting loss in hunger drive. According to this analysis, the functions shown in Figures 1 and 4 represent speed decrements due to drive losses produced by feeding  $S$  specified amounts of food in  $G_1$ . The objections to this hypothesis are substantial and have been summarized elsewhere (Amsel, 1958a; Wagner, 1959). The empirical point of the objections is that  $R_2$  speed is not solely a function of  $G_1$  reward but, rather, depends upon the relation between the test reward and the expected reward. Undoubtedly, with very large reward magnitudes, satiation would contaminate FE scores based on performance differences following reward and nonreward. However, from previous results and from our results on speeds within the day, it seems likely that the contribution of drive losses to the FE scores was relatively small in the present experiments.

A second alternative account of FE phenomena is available using only concepts from earlier versions of the Hull-Spence theory. The central notion in this account is the anticipatory goal response ( $r_\theta$ ), which Spence (1956) and Amsel (1958a, 1958b) have used to represent the strength of incentive motivation ( $K$ ) for an instrumental response. Applying Spence's theory to the double-runway situation, it is expected that after sufficient rewarded training  $r_\theta$  will be conditioned to cues in  $R_1$  preceding  $G_1$  and also to cues in  $R_2$  preceding  $G_2$ . The principal assumption in the present proposal is that when the  $r_\theta$  is aroused in  $R_1$  and then not satisfied by reward in  $G_1$ , this  $r_\theta$  and its consequent excitement persist for some amount of time. If during this time the animal is permitted to perform a second response, the persisting  $r_\theta$  and its excitement add in to increase the net incentive motivation for this second response. Hence, an increase in  $R_2$  speed would be observed following nonreward in  $G_1$ .

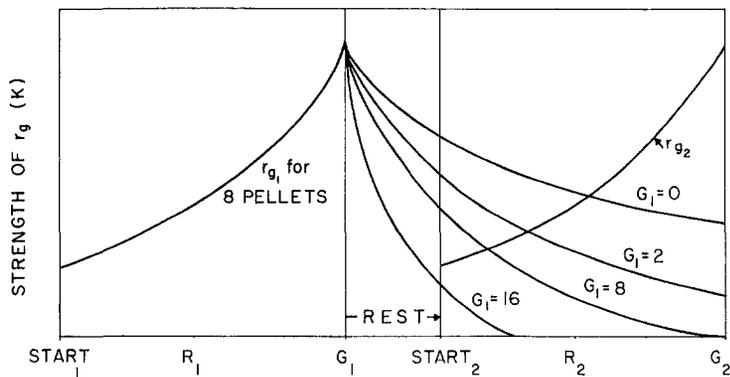


FIG. 5. A combined spatial and temporal graph representing the hypothetical strength of conditioned  $r_g$  and excitement along the first and second runways. (See text for explanation.)

In Figure 5 is shown the extension of this hypothesis to the case of tests with various amounts of reward at  $G_1$ . Figure 5 is a combined spatial and temporal graph representing the hypothetical strength of conditioned  $r_g$  and excitement along the first and second runways. The critical assumption reflected in the curves in Figure 5 is that the rate of decay over time of the conditioned excitement from the first runway is directly related to the reward  $S$  received in  $G_1$ . As an ordinal approximation, it may be assumed that the net incentive motivation for the second response is given by some additive combination of the strength of  $r_g$  specifically conditioned in the second runway and the  $r_g$  persisting from the first runway. These minimal assumptions would imply that  $R_2$  speed would be inversely related to the amount of reward given in  $G_1$  on test trials. Thus, following training with 8 food pellets, tests at 0 and 4 pellets in  $G_1$  would result in faster  $R_2$  speeds, while tests at 16 pellets would result in slower speeds.

It may be noted that this extension of Spence's theory of incentive motivation accounts for the known data on the FE phenomena without introducing the concept of frustration. It is possible, of course, that other evidence (e.g., from discrimination learning and partial reinforcement) will require the introduction of a frustration construct into the theory developed by Hull and Spence. For the moment, however, it remains an open question.

#### SUMMARY

The frustration effect (FE) reported by Amsel was studied in these experiments. The issues under investigation were (a) whether the amount of FE varies directly with the reduction in reward on test trials, and (b) whether two frustrating events occurring close together in time summate in their effects upon subsequent performance. In the first experiment, rats were trained in a three-link runway with rewards of 8, 8, and 1 food pellets in the three respective goal boxes. During an extensive test series, rewards of 0, 1, 4, 6, 8, 12, or 16 pellets were presented in various combinations at the first and second goal boxes, and FE was estimated by the change in response speed in the runways immediately following the test reward.

The first finding was that the size of FE was larger the greater the reduction in reward on test trials. The substance of this finding was replicated in a second experiment employing a smaller value of reward (4 pellets) during training. A second finding was that tests with rewards larger than the regular 8 pellets produced decrements in speed of the next response. The third result was that the effects of reduced rewards in the first and second goal boxes appeared to summate in enhancing performance in the third runway. Within Amsel's frustration theory, the first finding requires that  $S$  learns to expect a specific amount of reward (or, alternatively, learns a specific  $r_g$ -amplitude) and that the

frustration reaction depends upon the discrepancy between the reward expected and the reward obtained. An alternative hypothesis was proposed in which the FE is considered to result from the perseveration of excitement from an  $r_g$  that is aroused by conditioned stimuli but then is not satisfied by the expected reward.

## REFERENCES

- AMSEL, A. Comment on "role of prefeeding in an apparent frustration effect." *J. exp. Psychol.*, 1958, **56**, 180-181. (a)
- AMSEL, A. The role of frustrative nonreward in non-continuous reward situations. *Psychol. Bull.*, 1958, **55**, 102-119. (b)
- AMSEL, A., & ROUSSEL, J. Motivational properties of frustration: I. Effect on a running response of the addition of frustration to the motivational complex. *J. exp. Psychol.*, 1952, **43**, 363-368.
- SEWARD, J. P., PEREBOOM, A. C., BUTLER, B., & JONES, R. B. The role of prefeeding in an apparent frustration effect. *J. exp. Psychol.*, 1957, **54**, 445-450.
- SPENCE, K. W. *Behavior theory and conditioning*. New Haven: Yale Univer. Press, 1956.
- SPENCE, K. W. The roles of reinforcement and non-reinforcement in simple learning. In K. W. Spence (Ed.), *Behavior theory and learning*. Englewood Cliffs, N. J.: Prentice-Hall, 1960.
- WAGNER, A. R. The role of reinforcement and non-reinforcement in an apparent frustration effect. *J. exp. Psychol.*, 1959, **57**, 130-135.

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