EXPECTATION AND RESISTANCE TO EXTINCTION UNDER PARTIAL REINFORCEMENT AND RISK-TAKING

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Like most studies of extinction after partial reinforcement, our earlier experiments have not required *S* to risk anything but his own effort; *S* either won or did not win, but did not lose, money each time he responded.[1] The present experiment introduced some risk-taking, that is, *S* could lose money. He was given an initial stake, the amount of which, he was led to believe, he could either add to or decrease each time be played the apparatus. The purpose of the experiment was to determine what effect risk-taking would have on resistance to extinction, particularly whether risk-taking would grossly modify the relation, found in earlier studies, of resistance to extinction and percentage of reinforcement.[2]

Method: (1) *Apparatus.* The apparatus has been described in detail elsewhere;[3] it is an electrical slot machine which can be prearranged to pay off on specified trials or plays. *S* inserts a chromium-plated disk into an aperture, pushes one button in each of four columns of four buttons, and pulls a lever. The machine makes 'business-like' noises, at the conclusion of which a disk is dropped into the pay-off tray if it is a pay-off trial.

(2) Design. Five percentages of reinforcement, 0, 11, 33, 67 and 100, were combined factorially with two magnitudes of reward, 1¢ and 5¢, making ten conditions in all. Separate groups of 30 *S*s each were run under every condition. For all groups, the first nine plays made up the trials of 'acquisition.' During acquisition, the 0%-Group received no pay-offs; the 11%-Group was paid off only on Play 9; the 33%-Group was paid off on Plays 2, 5, and 9; the 67%-Group on Plays 1, 2, 4, 5, 6,

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[1] For a review of earlier studies see D. J. Lewis, Partial reinforcement since 1950: A selective review of the literature, *Psychol. Bull.*, 57, 1960, 1-18. The studies by the present authors include: D. J. Lewis and C. P. Duncan, Effect of different percentages of money reward on extinction of a lever-pulling response, *J. exp. Psychol.*, 52, 1956, 23-27; Expectation and resistance to extinction of a lever-pulling response as functions of percentage of reinforcement and amount of reward, *ibid.*, 54, 1957, 115-120; Expectation and resistance to extinction of a level-pulling response as a function of percentage of reinforcement and number of acquisition trials, *ibid.*, 55, 1958, 111-128; Vicarious experience and partial reinforcement, *J. abnorm. soc. Psychol.*, 57, 1958, 321-326.

[2] See particularly Lewis and Duncan, *opp. citt.*, 1956 and 1957.

[3] Lewis and Duncan, *op. cit.*, 1957, 115.

and 9; and the 100%-Group on all of the plays. After the ninth play, none of the *Ss* ever won again.

A record was kept of the total number of plays, and, in addition, the *Ss* of all Groups were asked to state their expectations of winning or not winning on every play. Secured to the front of the machine was a rating scale with the numbers 1 through 6 placed at equal intervals above a line. Above these numbers was the heading, "Expectation of winning or not winning." Corresponding to the numerical scale-points were the descriptions: "fairly sure of not winning," "mildly sure of not winning," "slightly sure of not winning," "slightly sure of winning," "mildly sure of winning," and "fairly sure of winning." On each play, before he pulled the lever, *S* called out the numerical value corresponding to his level of expectancy; these numbers were recorded by *E*.

(3) Instructions. First, *S* was told briefly how to operate the machine. He was to place a disk in the slot, push one button in each of the four columns of buttons, and then pull the lever. If he had picked the right combination of buttons, he was informed, the machine would pay off a disk. He was asked to state his expectation before each play. Then he was given the following instructions:

> Now each of these disks is worth 1¢ [or 5¢] and to start with, I shall stake you to 60 disks, so you have 60¢ [or $3.00] to begin with. This is your stake in this box [*E* indicates small box containing 60 disks at right side of apparatus.] You play the machine with disks from your stake. If the machine pays off—it pays off only one disk at a time—you will get back the disk you put in the machine, and in addition I shall give you a disk so you will have won 1¢ [or 5¢]. If the machine does not pay off, you will have lost the disk you put in the machine, so you will have lost 1¢ [or 5¢]. Thus you may win a lot more than you have to start with, or you may lose all you have. You can play as long as you wish. When you decide to quit, I shall give you 1¢ [or 5¢] for every disk you have in the box.

The *E* dropped a disk in the box each time *S* won. After *S* had decided to quit, he was paid off with money, if he had any disks left; given a plausible but false explanation of the machine; and told not to tell any other person how the machine operated or how much he had won.

(4) Subjects. The *Ss*, 300 in number, were drawn from introductory courses in psychology at Northwestern University and were assigned to the various experimental groups in turn as they appeared in the laboratory. Thirty *Ss* were assigned to each of the 10 groups.

Since the maximal number of plays that could be made by the *Ss* in the 0%-Group was 60 (the number of disks in the initial stake), all the *Ss* in any group who played through all their disks, including any won, were assigned a score of 60.

Results: (1) Number of plays. If partial reinforcement operated to produce greater resistance to extinction, then the number of *Ss* making the maximal number of plays (60) should be greater for the groups with the lower percentages of reinforcement than for groups with the higher percentages. To test for the presence of such a trend, a 2×2 table was constructed. The *Ss* (150) receiving the least reinforcement (those in the 0%, 11%, and half of those in the 33% Groups) and the *Ss* (150) receiving the most reinforcement (half of those in the 33%, and all those

in the 67% and 100% groups) were divided into two groups: those who played the maximal number of times (60) and those who stopped short of the maximum. Of the least-reinforced groups, 68.5 played the maximal number of times and 81.5 stopped short of the maximum. Of the more reinforced groups, 47.5 played the maximal number of times and 102.5 played less than that number. These frequencies yielded $\chi^2 = 6.198$, which is significant at the 2% level.

In another analysis, the number of plays made by each *S* was converted to a common logarithm (to permit comparison with previous studies) and an analysis of variance was performed on these transformed scores. Reinforcement was significant at the 5% level ($F = 2.60$, 4 and 290 *df.*). Neither amount of reinforcement ($F = 2.67$, 1 and 290 *df.*), nor the

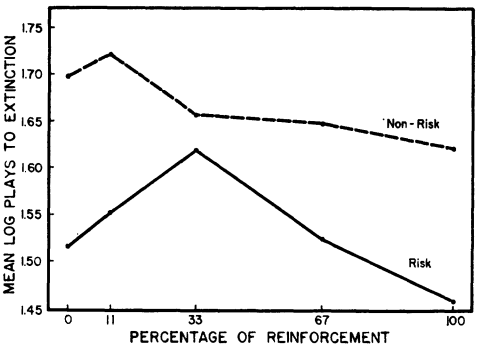

FIG. 1. MEAN LOG TRIALS TO EXTINCTION AS A FUNCTION OF PERCENTAGE OF REINFORCEMENT IN THE PRESENT (RISK) EXPERIMENT AND IN AN EXPERIMENT NOT INVOLVING RISK

interaction of amount and percentage ($F = 1.80$, 4 and 290 *df.*) was significant. Accordingly the results for the 30 *S*s rewarded with 1¢ and the 30 rewarded with 5¢ were combined at each value of percentage of reinforcement and are plotted as the lower curve shown in Fig. 1. In spite of some irregularities in the curve, there was, in general, less resistance to extinction on the part of groups with higher percentages of reinforcement.

The chief purpose of the present experiment was to determine if the element of risk, that is, the necessity of using one's stock of valuable tokens, produced any significant change in the function relating resistance to extinction and percentage of reinforcement. As a comparison with the present results, some data taken from an earlier study are plotted as the upper curve in Fig 1.[4] The *S*s represented in the upper curve were run

[4] Lewis and Duncan, *op. cit.*, 1957, 116. Note that only the groups from the 1957 study that were rewarded with 1¢ or 10¢ are used for comparison here.

under the same five percentages of reinforcement as were used in the present experiment, but without the element of risk, *i.e.* the *S*s either won or did not win, but did not lose, on each of the nine trials of acquisition. Of the 20 *S*s represented at each of the five points in the upper curve, half had been rewarded with 1¢, half with 10¢, for each disk they won; these subgroups were combined, since resistance to extinction did not differ significantly as a function of these two amounts of reward. As with the *S*s of the present study, any *S* from the previous study who had made more than 60 plays was assigned a score of 60.

The results of the two experiments, depicted in Fig. 1, were compared by an analysis of variance which is summarized in Table I. The first variable, risk vs. non-risk, represents the two experiments. As usual, the *F* for percentage of reinforcement was significant; in general, resistance

TABLE I

COMPARISON OF THE FUNCTION RELATING RESISTANCE TO EXTINCTION AND PERCENTAGE OF REINFORCEMENT IN THE PRESENT EXPERIMENT WITH THE FUNCTION FROM AN EXPERIMENT NOT INVOLVING RISK

Source	*df*	*MS*	*F*
Risk vs. Non-Risk	1	1.358	20.58*
Percentage of Reinforcement	4	.183	2.77†
Risk vs. Non-Risk × Percentage	4	.051	
Within-groups	390	.066	

* Significant at the 1% level. † Significant at the 5% level

to extinction decreased as percentage of reinforcement increased. The other two *F*-values from the analysis of variance are of more interest here. As Table I shows, the term for risk vs. non-risk was highly significant, but the interaction between risk vs. non-risk and the percentage of reinforcement did not approach significance. Clearly, there was less over-all resistance to extinction among *S*s in the present (risk) experiment, but the non-significant interaction indicates that the general shape of the function relating resistance to extinction and percentage of reinforcement was not greatly affected by this over-all difference between risk and non-risk conditions.

(2) Expectancies. The expectancies (verbal statements of confidence of winning on the next play) were Vincentized into thirds of the nine plays of acquisition and into tenths for the plays in extinction for each *S*. The mean expectancies during acquisition and extinction, with percentage of reinforcement as the parameter, are plotted in Fig. 2. The corresponding graph with amount of reinforcement as the parameter is not presented since this variable had little effect on expectancy-scores Descriptively, the

curves of Fig. 2 are very similar to those found in the earlier comparison-study.[5]

To determine the effect of the two main variables on changes in expectancies, two analyses of variance for trend were performed, one over the three blocks of trials in acquisition, the other over the third (last) block of trials in acquisition and the first, fifth, and tenth blocks of trials

TABLE II

ANALYSIS OF TREND OF EXPECTANCIES OVER TRIALS IN ACQUISITIÓN AND EXTINCTION

Source	Acquisition			Extinction		
	df	*MS*	*F*	*df*	*MS*	*F*
Percentage (P)	4	41.28	15.07†	4	30.64	10.60†
Amount (A)	1	.74		1	.78	
P×A	4	10.65	3.89†	4	9.94	3.44†
Between *S*s (error)	290	2.74		290	2.89	
Trials (T)	2	2.73	5.46†	3	86.30	115.07†
T×P	8	4.86	9.72†	12	6.37	8.49†
T×A	2	.59	1.18	3	2.67	3.56*
T×P×A	8	.44		12	.63	
Pooled *S*s×T (error)	580	.50		843‡	.75	

* Significant at the 5% level.
† Significant at the 1% level.
‡ Reduced by 27 *df* (9 *S*s×3 extinction-trials) because 9 *S*s did not complete acquisition, so had no expectancy scores during extinction.

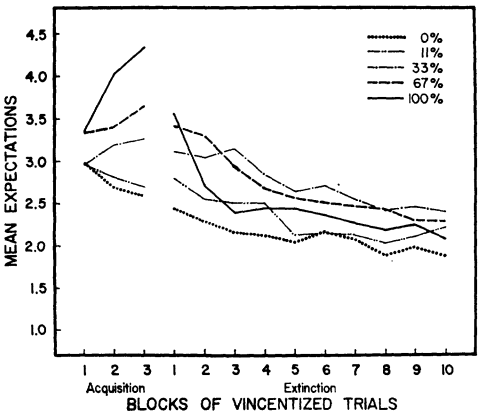

FIG. 2. MEAN EXPECTANCY-SCORES OVER VINCENTIZED BLOCKS OF TRIALS DURING ACQUISITION AND EXTINCTION WITH PERCENTAGE OF REINFORCEMENT AS THE PARAMETER

[5] Lewis and Duncan, *op. cit.*, 1957, 117. The results shown in Fig. 3 include expectancies from groups given all four amounts of reward (1¢, 10¢, 25¢, 50¢), but it was shown that expectancies did not vary significantly as a function of this variable.

in extinction. Both analyses are summarized in Table II. The results of both analyses are much the same. As a main effect, amount of reinforcement was not significant. Percentage of reinforcement was significant, as was the interaction of percentage and amount. This interaction was the result of a greater change in expectancy-scores with 1¢ reward than with 5¢ reward over the range from 0% to 100% reinforcement.

The terms of major interest in Table II are those for trials, and in particular the interactions of the main variables with trials. It can be seen that the term for trials and the term for interaction of percentage of reinforcement with trials are highly significant in both analyses. Expectancies changed over the course of both acquisition- and extinction-trials, and changed differentially as a function of percentage of reinforcement. These effects appear clearly in Fig. 2. Expectancies increased during acquisition in the 33%, 67%, and 100% Groups, but decreased in the 0% and 11% Groups. From the end of acquisition to the end of extinction, expectancies decreased in a manner that was almost directly related to percentage of reinforcement; the decrease in mean expectancy was 0.55, 0.53, 0.72, 0.90, and 1.23 for the 0%, 11%, 33%, 67% and 100% Groups, respectively.

In Table II, the interaction of amount of reinforcement with trials was not significant during acquisition, and was significant at only the 5% level during extinction; again, amount of reinforcement had little effect. The triple interaction, among the two main variables and trials, was not significant either in acquisition or extinction.[6]

Discussion. In our view, the present experiment, which involved risk-taking, yielded two findings worthy of note. As compared to an earlier experiment in which the element of risk was absent, there was, in the present study, (a) significantly less over-all resistance to extinction, but (b) no major change in the usual declining function relating resistance to extinction and percentage of reinforcement.

Concerning the first of these findings, less resistance to extinction, it should be noted that the *Ss* of the present study were run at a different time than the *Ss* of the earlier, non-risk, experiment. Thus, it is possible that the difference in resistance to extinction between the two experiments resulted from a difference in the populations from which the *Ss* were drawn. This does not seem likely. The *Ss* for all experiments are always drawn from the same introductory courses in psychology, and from all quarters of the academic year. Resistance to extinction in the present experiment was lower than it was in any of the three previous experiments

[6] These results on expectancy are similar to results in the earlier studies. *Cf.* Table 1, Lewis and Duncan, *op. cit.*, 1957, 118, and Table 2, 119.

in which the same apparatus was used to study various conditions combined with partial reinforcement, but in which the element of risk was lacking.[7] It seems reasonable to assume that *Ss* in the present study were influenced to stop playing the apparatus sooner than usual by the fact that continued playing meant risking the loss of all of their initial stake.

All five groups differentiated in terms of percentage of reinforcement showed numerically less resistance to extinction than the groups with which they were compared (see Fig. 1). Despite this, the usual inverse relationship between percentage of reinforcement and resistance to extinction was maintained. Although the relationship (lower curve in Fig. 1) is somewhat irregular, and seems to be slightly flatter than the curves reported in previous studies, there was no clear evidence that the function was much changed by the element of risk. In all situations that we have used with the present or with a similar apparatus, the general relationship between percentage of reinforcement and resistance to extinction has been a very stable phenomenon.

Finally, the results of the present experiment with regard to amount of reinforcement as a variable, and with regard to expectancy as a response—measure, are essentially the same as have been found earlier. Amount of reinforcement has had little influence on resistance to extinction when disks are valued at less than 50¢ each.[8] Expectancies have always changed differentially as a function of percentage of reinforcement during both acquisition and extinction.[9]

SUMMARY

Resistance to extinction in a situation involving some risk-taking was measured as a function of percentage of reinforcement and of amount of reward. Each of 300 *Ss* was provided with a limited stake of disks with which to play an electrical slot machine. If on any play the machine did not pay off, *S* lost a disk; if the machine paid off, *S* won an additional disk. For half the *Ss*, each disk was worth 1¢, for the other half, 5¢. These two amounts of reward were combined in a factorial design with five percentages of reinforcement; the machine paid off on either 0%, 11%, 33%, 67%, or 100% of the first nine trials. After these, the acquisitional trials, the machine never paid off again (extinction). The *Ss* stopped

[7] Lewis and Duncan, *op. cit.*, 1957; *J. exp. Psychol.*, 1958; *J. abnorm. soc. Psychol.*, 1958.

[8] Lewis and Duncan, *op. cit.*, 1957, 118.

[9] Lewis and Duncan, *op. cit.*, 1957; *J. exp. Psychol.*, 1958. But note that expectancies may not change if the *Ss* have only vicarious experience of winning during acquisition; see Lewis and Duncan, *J. abnorm. soc. Psychol.*, 57, 1958, 324.

playing whenever they wished, at which time they were paid with money for any disks remaining. The response-measures were total number of plays, and *S*'s expectancies, stated in numerical terms, of winning or not winning on each play.

The results were that resistance to extinction, as measured by number of plays, decreased as percentage of reinforcement increased. Resistance to extinction did not vary as a function of amount of reward. Expectancies changed differentially as a function of percentage of reinforcement during both acquisition and extinction. Resistance to extinction was significantly less than had been found in an earlier, comparable study in which the element of risk was lacking, but there was no evidence that risk effected any significant change in the usual inverse relationship between resistance to extinction and percentage of reinforcement.