Twelve-choice probability learning with payoffs[1]

FORREST W. YOUNG
UNIVERSITY OF SOUTHERN CALIFORNIA

Fifteen human Ss participated in a 12-choice probability learning experiment. There were three sets of probabilities (.14, .0725, .0375), and four sets of payoffs (1, 2, 3, and 4). These event probabilities and payoffs were combined in such a way as to give each event a unique expected value. The Ss' relative response frequencies were found to be monotonically related to the expected values.

In the two-choice, no payoff, noncontingent probability learning paradigm it has been well established that human Ss probability match (Estes, 1964). It has also been established that as the number of choices is increased, the relative frequency of response exceeds the event probability for the more probable events. This "overmatching" effect depends on the number of events as was shown by Gardner (1958), who varied the number of events (from two to eight) while holding the probability of the most frequent event constant. He found that the prediction frequencies increased as a function of the number of events.

It has also been established that when monetary payoffs are introduced the relative frequency of response ceases to match the event probabilities. Myers and his associates (Myers, 1961; Myers, Fort, Katz, & Suydam, 1963) found that in the two-choice situation "overmatching" occurred when payoffs were introduced, and that as payoffs were increased, the Ss tended to more nearly maximize their earnings.

In a recent series of experiments, Messick & Rapoport (1965a, 1965b) investigated the relationship between payoff and response frequency in a ten-choice paradigm. They found that the response frequencies were inconsistent with the probability-matching hypothesis, as had been previously established (Gardner, 1958; Myers, 1961). Messick and Rapoport presented two alternative hypotheses. One of these was a generalized probability-matching hypothesis which postulated that the *order* of the relative response frequencies will match the order of the event probabilities. The other hypothesis was an expected value hypothesis which stated that the order of the relative response frequencies will match the order of the expected values of the events, where the expected value of an event is defined as its probability of occurrence multiplied by its payoff (assuming no cost for incorrect predictions).

Messick and Rapoport found that their results were highly consistent with the expected value hypothesis, and that the probability-matching hypothesis did not apply to their results. To further test the relative merits of these two hypotheses, a 12-choice experiment was designed. The two hypotheses generate different predictions of the outcome of the experiment.

Method

The Ss were 15 undergraduates enrolled in introductory psychology classes. They were given course credit for their participation, and they reported individually to the experiment. The entire experiment was presented to the Ss via a Model 33 KSR Western Electric Teletype. The teletype acted as a remote terminal of the System Development Corporation's time-sharing system. A real time program was written in PLANIT which instructed the S in operating the teletype, which presented the experiment's instructions, which recorded the S's responses, and which presented feedback to the S. If the S did not understand a certain part of the instructions he was allowed to review that part.

The start of a trial was indicated when the teletype printed an asterisk. The S was instructed to indicate his prediction by typing one of the numbers 1 through 12. If any other response was made, the S was informed that he had made an error and to try again. Approximately 3 sec. after he made his prediction, the S was informed (a) whether he was right or wrong, (b) which event had occurred on that trial, (c) how much that event paid, and (d) what his total earnings were up to and including that trial.

The S operated at his own speed, unless he took longer than 10 sec. to respond, in which case the teletype printed a message urging him to respond more quickly. The experiment lasted about 45 min.

There was one group of Ss. Each S was run 200 trials. The S was instructed to predict one of 12 events on each trial. If the prediction was correct the S received a certain number of "units" added to his total. No reference was ever made to monetary values, and the Ss were never led to believe that

Table 1. Event Characteristics

	Event Number											
	1	2	3	4	5	6	7	8	9	10	11	12
Pay.	1	2	3	4	1	2	3	4	1	2	3	4
Prob.	.0375	.0375	.0375	.0375	.0725	.0725	.0725	.0725	.14	.14	.14	.14
Exp. V.	.0375	.0750	.1125	.1500	.0725	.1450	.2175	.2900	.1400	.2800	.4200	.5600
Freq.	.060	.043	.066	.076	.057	.070	.073	.107	.073	.093	..130	.146

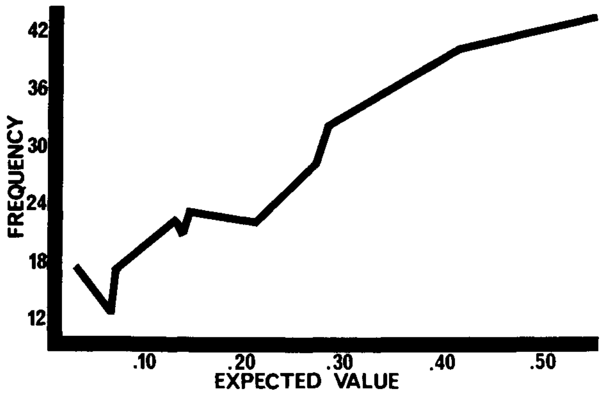

Fig. 1. Mean relative choice frequency of 15 Ss over trials 181-200 as a function of expected value of the chosen event.

money was involved. The number of units depended on the particular event predicted. If the prediction was incorrect, the S received no "units," and had none subtracted. Table 1 presents the payoffs used for each event.

Each S received a unique series of events which was generated by the computer while the S received his instructions. The event series was generated according to the event probabilities presented in Table 1. Each S also received an arbitrary renumbering of the events, so that response biases would be avoided. Throughout the entire experiment, the S could see the preceding series of events and predictions.

In addition to the payoffs and the event probabilities, Table 1 also presents the expected value of each event. The expected value is simply the payoff multiplied by the probability, since there was no cost for an incorrect prediction.

Results and Discussion

The mean relative choice frequencies for the 15 Ss were obtained over the last 20 trials. These frequencies were converted to proportions and are presented in Table 1.

To test the expected value hypothesis, Kendall's tau was calculated between the rank ordered choice frequencies and the rank ordered expected values. It was found to be highly significant ($Z = 3.76$, $p < .0001$). The Spearman rank order correlation coefficient was .95.

To test the generalized probability-matching hypothesis, Kendal's tau was calculated between the ranked choice frequencies and the rank ordered event probabilities. The tau (corrected for ties) was not significant.

The relationship between choice frequency and expected value is indicated in Fig. 1. It is clear from the figure, and on the basis of the statistical analyses, that the choice frequencies strongly reflect the expected values of the events, and that probability-matching (even in the generalized sense) was not found. These results fall closely in line with those of Messick & Rapoport (1965a).

It is worthwhile to note that there is an alternative hypothesis which could account for the results of this experiment, as well as those of Messick and Rapoport's experiment. It may be that the Ss are responding on the basis of their subjective expected utility (SEU) of the events. The SEU of an event is often defined as the subjective probability of the event multiplied by the utility of the event, where subjective probability is a monotonic function of probability, and utility is a monotonic function of the payoff of the events.

In the experiment reported here and in Messick and Rapoport's experiments, the expected value hypothesis and the SEU hypothesis lead to the same predictions, and it is difficult at best to design an experiment where this is not the case. Research is currently under way, however, which involves an attempt to obtain the SEU function in a multi-dimensional scaling experiment (Shepard, 1962; Cliff, Pennell, & Young, 1966), and then using it to predict the results of a multiple-choice probability learning experiment similar to the one reported here.

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Note

1. The generous assistance of System Development Corporation in providing free computer time is gratefully acknowledged.