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ABSTRACT

Performance expectancy and satisfaction were investigated in terms of the rate of change in performance outcomes. In a two-by-two factorial design, the direction (improving or deteriorating) and rate (accelerating or decelerating) of change in performance were manipulated using false feedback in a computerized math game. In accord with performance expectancy predictions, a significant main effect of the direction of change and a significant interaction between the direction and rate of change were found, with fewest errors occurring in the decelerating improvement condition. In accord with performance satisfaction predictions, a significant main effect of the second derivative was found, with more dissatisfaction reported in the accelerating deterioration and decelerating improvement conditions. (Author)

The Effects of Rate of Change in Performance

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Rate of Change in Performance

The Effects of Rate of Change in Performance

There is a considerable body of research focusing on the pattern of change in performance outcomes as a determinant of satisfaction with performance and/or expectation of future performance levels. Much of that research has focused on effects of the direction of change in performance (improving or deteriorating). The rate of change in performance (accelerating or decelerating) however, has not been the focus of systematic investigation.

The most relevent expectancy research will be reviewed first. Most of this research has focused on primacy and recency effects, that is, the impact of the initial or most recent performance outcomes on estimates of future performance levels. Probability learning research has produced three findings of particular relevance to the study described below: (1) individuals, given a sufficiently long time, will come to anticipate outcomes with a probability exactly proportional to true probabilities; (2) such expectations are accurate because individuals can discern complex patterns of change; and (3) most evidence supports a recency hypothesis, whereby recent outcomes have a greater impact on expected performance levels (Estes, 1972).

In contrast to probability learning research, social psychological expectancy research has used experimental tasks which are more ego-involving and which use different types of performance outcomes. In spite of these differences, similar evidence of primacy and recency effects has been found. None of these studies, however, used as dependent variables both positive and negative directions and rates of change in performance outcomes. These studies which came closest to doing so will be examined in more detail below.

Jones et al. (1968) studied the effects of the direction of change in performance. Using false feedback and holding overall performance constant, three conditions were created: ascending (improving performance), descending, and random. Jones et al. found a primacy effect when subjects predicted a partner's performance. In the experiment most relevant to the present study, a recency effect was found when subjects predicted their own performance; subjects in the ascending condition expected fewer errors on a second problem series than subjects in the descending or random conditions. Jones et al., then, used improving and deteriorating performance outcomes to predict performance expectancy levels.

Brickman and Hendricks (1975) conducted a study closely related to the present study. Their dependent measures included both performance satisfaction and a measure of performance expectations. Their independent variables included rates of change in performance outcomes. They restricted their attention, however, to one direction of change in performance outcomes: improving rather than deteriorating.

Holding overall performance constant, Brickman and Hendricks used two false feedback conditions: "gradual" and "sudden" improvement. In the latter condition, performance was consistently poor for the first half of the trials, consistently good for the second half. In comparison to suddenly improving subjects, subjects in the gradual improvement condition were somewhat less satisfied with their test performance and more confident of their capacity to master similar tasks. Capacity to master similar tasks is not a direct measure of expectations for performance on the same task. These results do suggest, however, that the recency model of performance expectations and satisfaction may not be sufficient to explain the effects of the rate, as well as the direction, of change in performance outcomes.

Brickman and Hendricks, however, studied a particular kind of rate of change in performance. In their sudden improvement condition, a jump in performance, typical of some kinds of learning, occured between trials 7 and 8. For the other trials in this condition, the rate of change was near zero. In their conclusions, Brickman and Hendricks suggested that future research vary systematically the second derivative of performance, that is, acceleration or deceleration in the rate of change in performance that a person experiences over time.

In the present study, as in the previous studies, false feedback on a multiple-trial, experimental task was used, holding overall performance constant. A two-by-two factorial design was used. The first factor was the direction of change in performance (improving or deteriorating). The second factor was the rate of change in performance (accelerating or decelerating). Primary dependent measures were satisfaction with past task performance and expectations for future performance at the same task.

Expectancy predictions. Hypotheses concerning expectations are presented first. Jones et al. found that improving performers expect fewer errors than deteriorating performers. Similar results were predicted in the present study, where they would appear as a main effect for the direction of change in performance outcomes.

The rate of change, in performance outcomes, was predicted to interact with the direction of change. This prediction concerning expectations was based, for the two improving conditions on Brickman and Hendricks' "similar task capacity" results. Subjects in the decelerating improvement condition were predicted to expect higher future performance levels (fewer errors) than subjects in the accelerating improvement condition. The opposite pattern of results was predicted in the two deterioration conditions; subjects in the accelerating deterioration condition were predicted to expect more errors than subjects in the deccelerating deterioration condition.

The reasoning behind this predicted interaction is as follows. When the rate of change decelerates, conclusions about task performance can be drawn. Decelerating improvement implies a ceiling effect, the task is, as far as is possible, mastered, and very small error scores are expected, even smaller than in the error scores in the accelerating improvement condition where no conclusions about mastery can be drawn because performance has not stabilized yet. Decelerating deterioration implies a floor effect; performance on the task will not get worse, so, although large error scores are expected, they are not as large as the error scores expected in the accelerating deterioration condition, where performance is rapidly worsening, and no floor is yet evident. When the rate of change accelerates, on the other hand, recent performance levels may be discounted because they are so different from the earlier performance trend.

Two alternate hypotheses concerning performance expectancy were also tested: the primacy and recency models. Confirmation of either of these hypotheses would cause a significant main effect of the direction of change; no significant main effect or interaction, involving the rate of change, would be found. Inspection of the pattern of mean differences, of course, would permit a distinction between the primacy and recency models. Neither the primacy nor the recency model was predicted to fit.

Satisfaction predictions. Performance satisfaction predictions will be discussed next. The fact that subjects were rapidly getting worse in the accelerating deterioration condition was predicted to cause strong dissatisfaction. Moderate amounts of dissatisfaction were also predicted in the decelerating improvement condition, because subjects' initially rapid rates of improvement had leveled off to near zero improvement in performance. Satisfaction with performance was predicted in the remaining two conditions. In the accelerating improvement condition the fact that subjects were getting better at an increasingly rapid rate was predicted to cause strong satisfaction. In the decelerating deterioration condition, the slow-down in deterioration was predicted to be moderately satisfying because it was a step in the right direction. The satisfaction predictions in the improving conditions are congruent with Brickman and Hendricks' data on the effects of "gradual" and "sudden" improvement. Both expectations and satisfaction, then, were hypothesized to be affected by the rate, as well as the direction, of change in performance outcomes.

Secondary hypotheses focused on true performance, recalled performance, ability, and attributions about the causes of performance differences between conditions by the end of the last trial. In accord with Brickman and Hendricks, no true performance differences at the end of the last trial were predicted. Jones et al. found that subjects could quite accurately recall the patterns of their false performance feedback. Similar results were predicted.

Ability and attribution variables were also considered. The experimental manipulation involved a math task. Subjects with unusually high math ability were predicted to expect fewer errors, because of their known ability to master such tasks. High math ability subjects were also predicted to be more satisfied, because they would assume that they were doing as well as anyone could.

An alternate ability hypothesis was suggested by Weiner and Kukla (1970), who found that low task ability was associated with heightened positive affect for success and lowered negative affect for failure. These results suggested that lower math ability subjects may exhibit higher levels of satisfaction than high math ability subjects in the improving conditions. This alternate hypothesis was tested.

Math ability was also predicted to be related to attribution. In accord with Weiner and Kukla's findings, it was predicted that success would be attributed internally, while failure would be attributed externally, although subjects with less than superior math ability might show a tendency to attribute failure internally and success externally.

Method

Subjects. Seventy-three graduate and undergraduate students volunteered to participate in the study. The data of three subjects, each from a different condition, were excluded from the analysis because these subjects suspected deception in the error score feedback. All subjects were paid $1.00.

Independent variables. A two-by-two factorial design with a nonequivalent control group was used. Math ability was used a a third, blocking variable. The manipulations of the two independent variables were incorporated into the false performance feedback given each subject after each of twelve trials in a computerized math game. The total error score for each subject was held constant, at 144 after the twelfth trial. Large error scores, of course, indicated poor performance. Error score false feedback after each trial provided the opportunity for manipulating the direction and rate of performance. The first derivative of the error scores on the twelve trials is the direction of change in performance. Positive first derivatives indicate deteriorating performance, as the number of errors is increasing. Negative first derivatives indicate improving performance, as the number of errors is decreasing. The second derivative of the error scores is the rate of change in performance. If the second derivative has the same sign as the first derivative, the rate of performance change is accelerating. If the second derivative is opposite in sign to the first derivative, the rate of performance change is decelerating. Thus the following four conditions were created: accelerating improvement, decelerating improvement, decelerating deterioration, and accelerating deterioration.

The control group had first and second derivatives of zero, indicating no consistent trend over time in performance scores. Table 1 presents the mean false feedback score for four blocks of three trials for each of the experimental conditions. A small random error term

Place Table 1 about here

(slightly larger in the control condition) was added to the error scores presented in Table 1 to increase the plausibility of the false feedback error scores. .hese random errors sum to zero across the twelve trials.

Total error scores in excess of 144 aroused suspicion in pre-tests, so the total error score was held constant at 144 for all subjects. In order to keep the total error score constant across conditions, it is necessary mathematically that the second derivative manipulation be quite small, with an average magnitude of ± 2. Any significant effect involving the second derivative is then both less likely and, should it occur, more suggestive of the importance of this factor.

Procedure. A computer terminal served as experimenter for all but the debriefing part of the experiment. The cover story and instructions were presented on the terminal. The subject's task was to guess the sixth in a sequence of numbers. Quadratic integer sequences were used, with a small random error term added to each number in the sequence, thus making the task one of estimation under conditions of uncertainty. After a practice sequence demonstrating the masking effect of the random noise, the subject was presented with twelve trials. The subject's response for each trial was recorded by the computer. After each response the program presented false feedback as to the "correct" answer and the subject's error score for that trial. Depending on whether the subject had over- or under-estimated the correct response, the "correct" answer was calculated by either adding to or subtracting from the subject's response, the subject's predetermined error score. Thus, the false feedback for each trial could correctly represent the direction of the subject's true error, if any, while still meeting the requirements of the experimental manipulation. The cumulative false feedback error score was also presented after each trial. After the twelfth trial the subject was asked to evaluate "how satisfied you were with your performance " --on a ten-point scale. The computer program explained the math game was over. The subject then filled out a questionnaire which contain the other primary dependent measure: "If you were to continue playing for another five trials, and then were to average your error scores for just those five sequences, what would your average error score per sequence be?".

Secondary dependent measures included the record of subjects' true error scores, subjects' recall in the final questionnaire of the error score received after each trial, and subjects' math aptitude S.A.T. or

G.R.E. scores. Subjects having G.R.E. or S.A.T. scores over 700 or having completed more than five math or statistics courses above the high school level were coded as having high, rather than moderate-math ability. Subjects were also asked to attribute performance in the computer game to (a) a stable ability, such as intelligence; (b) a learnable skill which would improve with practice, or (c) a mixture of the above or an external factor, such as luck.

Results

True performance. Analysis of variance revealed no significant effects of the false feedback performance scores on the total true error scores. Subjects in the accelerating deterioration condition made slightly fewer true errors. Any difference between conditions, then, cannot be attributed to true performance differences.

Recall of false feedback. Analysis of variance using total recalled errors as the dependent variable revealed no significant between-condition differences. Subjects in the accelerating deterioration condition remembered slightly more errors than subjects in the other three conditions. Slight evidence of recall distortion was found when the mean recalled and actual false feedback error scores for each block of three trials were compared. Deteriorating subjects showed a slight tendency to over-estimate early errors and under-estimate later errors, as did subjects in the random condition. Subjects in both improving conditions slightly over-estimated errors in all trials. None of these between-trial or between-condition differences were significant. Any effects of the first and second derivatives of the false feedback could not be attributed to differences in recall, as subjects' recall is quite accurate.

Expectations. Table 2 presents the expectation and satisfaction results. As predicted, subjects in both improving conditions expected

Insert Table 2 here

fewer errors on future trials than subjects in both deteriorating conditions. This main effect of the first derivative, that is, the direction of change in performance, was significant, ($F (1,61) = 32.10$, $p < .001$), and was in accord with the results of Jones et al. Contrary to the recency model, however, and in accord with predictions, there was a significant interaction between the first and second derivatives, ($F (1,61) = 9.27$, $p < .005$). The most abrupt jump from the recent feedback trend was evident in the accelerating improvement condition. In accord with Brickman and Hendricks' "similar task capacity" results, subjects in the accelerating improvement condition had a higher mean expected error score than subjects in the decelerating improvement condition. No such reversal from most recent feedback trends was found among deteriorating subjects. Subjects in the accelerating deterioration condition expect more errors than subjects in the decelerating deterioration condition. This pattern of expectation results fit predictions exactly.

The control group, which experienced no systematic changes in performance over time, was expected to exhibit an expectation level intermediate between the improving and deteriorating performers. As expected, the control group mean was not significantly different from the average of the other four conditions and was, in fact, quite close to the actual false feedback mean of 12. The control group was not significantly different from the other four conditions in the analysis of any of the other primary or secondary dependent measures.

Satisfaction. The second derivative of the error scores, that is the rate of change in performance, had a significant main effect on satisfaction with performance, ($F(1,61) = 4.00$, $P < .05$), because of the unexpectedly strong dissatisfaction (mean = 2.86) in the accelerating deterioration condition. The pattern of means, however, was as predicted, with the lowest level of satisfaction in the accelerating deterioration condition and the second lowest level of satisfaction in the decelerating improvement condition. Higher satisfaction levels were found in the decelerating deterioration condition, and the highest level in the accelerating improvement condition.

Math ability. Math ability was added as a third factor in the analysis of both the expectation and satisfaction data. In both cases, a main effect for math ability was found. Subjects with high math ability expect lower error scores ($F(1,61) = 12.76$, $P < .001$) and are slightly, not significantly, more satisfied with their performance, ($F(1,61) = 3.89$, $P < .10$). No interactions with the math factor were found. However, in accord with Weiner and Kukla's results, in the accelerating improvement condition, subjects with moderate math ability were slightly more satisfied than high math ability subjects. This difference was not significant and this pattern of results was not present in any of the other conditions.

Attributions. Although differences were not significant, the predicted pattern of attribution results was found. As in Weiner and Kukla's findings, subjects in the improving conditions showed a slight and nonsignificant tendency to attribute performance internally, to a learnable skill. Subjects in the deteriorating and random conditions showed a slight and nonsignificant tendency to prefer attributions to mixed or external causes.

Discussion

The first derivative had a main effect on performance expectancy as predicted by the recency model. In addition, and contrary to the recency model, a significant interaction between the first and second derivatives was found. This latter finding is striking in light of the small magnitude of the second derivative manipulation. It suggests that the rate, as well as the direction, of change in performance is an important determinant of performance expectations. These findings also suggest that revisions of the recency model of expectancy may be necessary when the effects of both first and second derivatives of performance are considered.

The rate of change also had a significant main effect on satisfaction with performance. In light of the small magnitude of the second derivative manipulation, it also suggests that the second derivative of performance should be studied further.

The predicted pattern of expectancy and satisfaction, based on the findings of Brickman and Hendricks, was found. The relationship between satisfaction and expectations is of particular interest in one of the four conditions. Subjects in the decelerating improvement condition reported the highest performance expectations, that is, the fewest expected errors, and the second lowest level of satisfaction. The combination of high expectations and low satisfaction under conditions of decelerating improvement has an interesting parallel in sociological theory. Davies (1962) found that revolutions were most likely to occur when a long, gradual increase is followed by a sudden drop in prosperity. Although the sudden drop may be necessary for revolution on a national scale, the combination of high expectations, due to a long period of rising prosperity, and sharp dissatisfaction, due to the gap between expectations and reality, occured when the increase in prosperity slowed down. Further research on the relationship between satisfaction and expectations might focus on the first and second derivatives of economic, as well as task, performance.

The math ability and attribution results were predominantly in accord with the findings of Weiner and Kukla. Although the direction of change in performance clearly affected these variables, there was no evidence that the rate of change in performance had any such effect.

In spite of the small magnitude of the manipulation, the second derivative affected both expectations and satisfaction with performance, producing a pattern of results which the recency model is not sufficient to explain. As Brickman and Hendricks suggested, the second derivative does appear to offer an interesting avenue for future research.

Reference Notes

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TABLE 1

Mean False Feedback Score for Four Blocks of Three Trials in Each Condition

Condition	Mean Error Score For Each Block of Three Trials
Accelerating Improvement	18, 16, 11, 3
Decelerating Improvement	21, 13, 8, 6
Decelerating Deterioration	3, 11, 16, 18
Accelerating Deterioration	6, 8, 13, 21
Control	12, 12, 12, 12

TABLE 2

Future Error Expectations and Satisfaction with Performance After Twelve False Feedback Trials

	Condition[a]			
	Accelerating Improvement	Decelerating Improvement	Decelerating Deterioration	Accelerating Deterioration
Mean Expected Error Score	10.29	7.43	12.93	14.50
Satisfaction[b]	4.43	4.00	4.36	2.86

[a]For each condition, N=14.

[b]The higher the score, the more satisfied the subject.