Joint effects of mean and variance of run lengths on a non-feedback probability learning task

JOHN C. MUNSON and FREDERICK L. NEWMAN,¹ New Mexico State University, Las Cruces, N. Mex. 88001

The mean and variance of run length were varied in a two-choice, nonfeedback, probability learning task. Contrary to a feedback situation, the low variability groups showed less negative recency than the high variability groups. Furthermore, differences in recency between low- and high-mean groups were suppressed.

Of considerable interest in the study of probability learning is the effect of mean and variance of event run length on two-choice probability learning tasks. Generally, it has been established that the probability of predicting a particular event tends to diminish as a function of the number of like events that have occurred in succession. This negative recency was initially reported by Jarvik (1951). Recent investigations have shown that this phenomenon of negative recency is in some way inversely related to the length of the run. Jones & Myers (1966) and Gambino & Myers (1966) have shown a tendency toward positive recency as run variability increases. The seemingly contradictory tendency toward higher negative recency using shorter run lengths has been attributed to the fact that shorter run lengths foster a greater number of reinforcements for the prediction of the alternate event during the same number of trials than do the longer length run groups. Similarly, the tendency toward positive recency using highly variable run lengths can be explained by the fact that in unstable run situations, the concept of run length is not properly formed and responses are based primarily on immediately preceding events.

The most frequently used experimental technique in probability learning is that of the simple noncontingent event schedule with some type of feedback to S. Inherent with this approach is the problem of differential reinforcement of the alternative event strategy between run groups. In allied studies in psychophysics, however, considerable work has been done in the field of nonreinforced sequential effects. In particular, a study by Verplanck, Collier, & Cotton (1952) indicates strong sequential dependencies of events within runs. This would seem to indicate the applicability of an experimental context employing a simple

signal-detection procedure for the investigation of the nonfeedback probability learning situation suggested by Gambino and Myers.

PROCEDURE

The procedure was suggested as the auditory analogue of a similar investigation by Kinchla (1964). For each S, the experiment was divided into two parts. Initially, S was asked to listen for a tone when the signal light came on and to report to the control room via intercom whether a high or low tone had occurred. For this period, S was presented a series of alternating high and low tones. The tones were slowly attenuated until the detection probability = .75. To initiate the second part of the experiment, S was read a standard set of neutral instructions explaining that the essential difference between the coming sequence and the previous one was that it was no longer necessary to use the intercom; rather, responses would now be recorded on the recorder facing him. He was asked to mark exactly one of the four possible choices on the template of the recorder representing the four intervals, "definitely heard a low tone" to "definitely heard a high tone." The S was asked to make a response whenever the stimulus light came on. For the second phase of the experiment, S was presented 500 trials over a period of 50 min. A trial was divided into a 2½-sec interval for the presentation of the tone and an equivalent interval for the response. During the first interval, the signal light came on followed after 1 sec by the stimulus which lasted 0.1 sec. After the light extinguished, S recorded his response.

DESIGN

The experiment was a modified two-choice signal-detection task. Factorially, four experimental groups were established differing with regard to the mean ($\mu = 7.5$ and 15) and standard deviation ($\sigma = 1$ and 4) of the high- and low-tone runs. Sequences of runs were generated randomly from a binomial approximation of the normal distribution with the desired mean and variance. From the sequence of random numbers established in this manner, high and low tone values were assigned to alternate numbers.

As was noted above, S's level of certainty was adjusted to .75 by attenuating the tone until it was heard only three-fourths of the time. Experimentally, this level of certainty was further reduced by randomly assigning

20% of the 500 trials to blank trials in which no tones were presented. Thus, on any one trial, S heard a tone with a probability of .6.

APPARATUS

During the experiment, S wore a Clark Model TC headset through which the stimulus was presented. Background noise was provided by a Grason-Stadler (901B) noise generator set for Gaussian noise at approximately 80 dB. The stimulus tones were added over the background noise by selectively switching in one of the two Hewlett-Packard (Model 22AB) oscillators. The oscillators were set at 500 Hz and 1 KHz. Signal amplitude was controlled through the use of decade attenuators. The onset of a trial was signaled by a smooth green light facing S. Responses were recorded on a modified Gerbrands event recorder mounted in a desk at which S sat.

SUBJECTS

Thirty-two males and 32 females, recruited from the introductory psychology classes of New Mexico State University, were randomly assigned to one of four experimental conditions. Eight additional Ss were rejected due to equipment failure or to apparent hearing loss on the 1-KHz tone.

RESULTS

Analysis of the data was facilitated by partitioning the runs into thirds to represent run scores for the early, middle, and late run behavior. These run scores were then cumulated for each S. There were significant linear ($F = 15.7$, $df = 1/60$, $p < .01$) and quadratic ($F = 102.5$, $df = 1/60$, $p < .01$) trends for the ordinal position main effect, indicating a positive slope in the event score distribution. The significant quadratic trend for this variable indicates an overall negative recency effect. A significant departure from the quadratic trend of the ordinal position effect was noted for the mean groups with the low mean groups showing significantly lower overall early errors than the high groups ($F = 18.3$, $df = 1/112$, $p < .01$). This is most clearly shown in Fig. 1, where the two panels represent the significant first-order interactions of mean ($F = 5.53$, $df = 2/112$, $p < .01$) and variance ($F = 4.94$, $df = 2/112$, $p < .01$) with the ordinal position variate.

Contrasts between the two mean groups did not reveal significant differences between the high and low groups with regard to the intermediate run scores. The high and low variability groups did, however, show significant differences ($F = 8.5$, $df = 1/112$, $p < .01$) on the late run scores, indicating significantly different recency effects between these groups, with the low-variability group demonstrating a marked tendency toward positive recency. In all cases, there were no significant differences between groups on intermediate run behavior.

Fig. 1. Interaction of mean and variability groups as a function of run position.

DISCUSSION

As was observed before, early run scores for all groups are significantly lower than either intermediate or late run scores. This is to be expected in that the optimal strategy for each S is still weighted heavily for the prediction of the previous event, particularly so due to the random nature of the length of runs. Indeed, this is an essential feature of the k-span model of Burke & Estes (1957), where S bases his response on any one event as a result of the last k events. The early run scores for the shorter run length groups were significantly lower than those of the groups exposed to longer run lengths, while no significant differences were noted in the late run scores between the groups. It would seem, then, that there is a tendency on the part of the short run groups to persevere the response favorable to the last tone run heard.

As was suggested by Gambino & Myers (1966), designs employing feedback techniques increase the number of reinforcements for the prediction of the alternate event for the short run groups. In the present context, feedback to S was eliminated with the net effect that differences in recency disappeared between groups with different mean run lengths. This seems to support the conclusion that the differential amount of reinforcement between groups is responsible for differences in recency formerly attributed to mean run length. However, this conclusion may be more relevant to detection psychophysics than to probability learning experiments, due to the notable lack of explicit reinforcement. Perhaps the most salient feature in the results of the nonfeedback design is the increased negative recency effect with the high variability groups. It would appear that an S operating under uncertainty due to both the stimulus

and run stability seems to choose a strategy involving the selection of the alternate event to an increasing degree shortly after the mean of the run length distribution. As an extension of the work of Verplanck, Collier, & Cotton (1952) with sequential dependencies, the concept of negative recency in probabilistic learning models may be directly associated with the declining critical ratios reported by these authors. They found statistically significant nonindependence when as many as 10 responses intervened between correlated responses. This appears to be an accurate observation for relatively stable run sequences. However, as the variability of the run lengths increases, there is a decline in the sequential dependencies. In a later study by Collier & Verplanck (1958), the degree of dependency in run sequences was found to be directly associated with the relative

strength of the stimulus. In the traditional two-choice probability learning situation, S is presented with what might be considered to be a relatively strong stimulus in the context of a detection experiment. It would seem, then, that the sequential dependencies reported in the psychophysical literature are extensions of effects found in the context of probability learning experiments.

REFERENCES

- BURKE, C. J., & ESTES, W. K. A component model for stimulus variables in discrimination learning. *Psychometrika*, 1957, 22, 133-145.
- COLLIER, G., & VERPLANCK, W. S. Nonindependence of successive responses at the visual threshold as a function of interpolated stimuli. *Journal of Experimental Psychology*, 1958, 55, 429-437.
- GAMBINO, B., & MYERS, J. L. Effect of mean and variability of event run length on two-choice learning. *Journal of Experimental Psychology*, 1966, 73, 56-67.
- JARVIK, M. E. Probability learning and a negative recency effect in the serial anticipation of alternate events. *Journal of Experimental Psychology*, 1951, 41, 291-297.
- JONES, M. R., & MYERS, J. L. A comparison of two methods of event randomization in probability learning. *Journal of Experimental Psychology*, 1966, 72, 909-911.
- KINCHLA, R. A. A learning factor in visual discrimination. In R. C. Atkinson (Ed.), *Studies in mathematical psychology*. Stanford, Calif.: Stanford University Press, 1964. Pp. 233-249.
- VERPLANCK, W. S., COLLIER, G. H., & COTTON, J. W. Nonindependence of successive responses in measurements of the visual threshold. *Journal of Experimental Psychology*, 1952, 44, 273-282.

NOTE

1. Now at Psychology Department, Box 8185, University of Miami, Coral Gables, Florida 33124. Reprint requests should be addressed to Dr. Newman.

Sound coding in verbal learning with and without restrictions on decoding

WILLIAM E. FORRESTER¹ and
NORMAN E. SPEAR, Rutgers University,
New Brunswick, N.J. 08903

A transfer design was used to assess the hypothesis that Ss may encode response terms as pronounceable sounds in learning a paired-associates list. The results indicated that the facilitative effects of sound coding are greatly diminished if S must use different

decoding rules in learning original and transfer lists.

Underwood & Erlebacher (1965, Experiment 6) provided evidence that response items in a verbal-learning task may be encoded as pronounceable sounds even though Ss are required to spell responses aloud at recall. The procedures used to demonstrate this coding process conformed