

In his studies of shuttle avoidance learning to an air-blast US, Ray (1966a, b) reported very rapid and nonincremental learning by rats. It can be argued, however, that Ray's use of a 5/6 criterion of "learning" is excessively lenient, making his conclusions possibly misleading with respect to the issue of nonincremental learning. Ray tested for nonincremental learning by comparing the number of avoidance responses in the first and second halves of the block of intermediate trials (the "oscillation sequence") between the first avoidance and the last escape before reaching the 5/6 criterion. Ray reported both significant (1966b) and nonsignificant (1966a) t-values for this comparison, and he cited both as evidence of nonincremental or all-or-none learning. He also reported (1966b, p. 434), "...there were many fewer avoidance responses in the second half than in the first half of the oscillation sequence."

In our study of avoidance learning with electric shock and air-blast US (Polidora & Boyer, 1967), squirrel monkeys learned more rapidly to avoid air-blast than continuous or discontinuous shock US,

Testing for stationarity with a 5/6 criterion also revealed insignificant t-values, indicating nonincremental learning in all groups of monkeys. But testing with a run-of-10 (cf., Theios & Dunaway, 1964) or even a run-of-6 criterion, obviously more convincing evidence of "learning" having occurred, the t-values for all groups were significant ($p < .02$), indicating nonstationarity or gradual learning. Obviously one important issue is the selection of an adequately stringent criterion of "learning" in testing for stationarity. I do not believe Ray has yet provided sufficiently convincing evidence that rats learn nonincrementally to avoid air-blast.

References

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Reply to Polidora: Continued evidence of non-incremental acquisition by A. Joseph Ray, Jr. Carleton University, Ottawa, Ontario

Polidora implies that nonsignificant and significant t tests may not both sustain a nonincremental interpretation of shuttle-avoidance acquisition. It must be made clear that any statistical test is weak evidence for all-or-none learning, for only those Ss which oscillate between success and failure, and thus are not strictly nonincremental learners, can be evaluated by this technique. However, 15 rats of 29 that learned in the first experiment (Ray, 1966a) shifted abruptly (that is, with no oscillation) from escape responding to avoidance responding. In the second study (1966b), with many rats as young as 60 days (shuttle-avoidance learning improves with age), 14 of 45 that learned did not oscillate. This is good evidence of nonincremental learning if performance is similar when a more stringent criterion is used.

Did those which oscillated reach criterion incrementally? If they did, the paired t test would show that the proportion of avoidance responses to total number of trials in the second half of the oscillation sequence was significantly greater than the proportion of avoidance responses in the first half of the oscillation sequence. There are, however, two additional alternatives: (1) that the avoidance responses are equally distributed in either half of the oscillation sequence (stationarity) in which case the value of t would be close to zero, and (2) that there are significantly more avoidance responses in the first half

of the oscillation sequence than in the second half, in which case t would be positive and significant.

The first experiment supported alternative (1): Avoidance responses were equally distributed on either side of the midpoint of the oscillation sequence, and t was close to zero. In the second experiment, which had fewer non-oscillating learners, the first half of the oscillation sequence had significantly more avoidance responses than the second half, resulting in a positive, significant t value. Neither finding sustains the incremental point of view.

Another datum of importance in this context is the Pearson correlation coefficient between Trials to Criterion and Total Errors to Criterion. The coefficient, 0.970, is extremely high, and indicates that the two dependent variables are nearly equal for each S. The only behavioral fact which would account for such a situation is elimination of the oscillation sequence, for, as should be clear, what makes Trials to Criterion greater than Total Errors to Criterion is the interspersing of successes, before criterion—the oscillation sequence. When there is no oscillation, learning is all-or-none, and a correlation coefficient between Trials to Criterion and Total Errors will be 1.00.

Selection of a performance criterion ought to take into consideration the number of trials necessary for most Ss to acquire the response. On the basis of pilot

Summary of performance of the same rats to different learning criteria in air-blast shuttle avoidance

		five out of six (n = 49)	Criterion five out of five (n = 49)	seven out of seven (n = 33)
mean total errors		7.10	8.47	9.00
mean trials to criterion		9.26	12.37	15.50
mean length of oscillation sequence		7.77	9.52	12.90
Total	first half	59	102.5	104
Avoidance		$\chi^2=3.24$ $p> .05$	$\chi^2=1.03$ $p> .20$	$\chi^2=.55$ $p> .50$
Responses	second half	41	88.5	115

data, it was clear that avoidance responding often appeared by the third trial. The 5/6 criterion was then selected to allow for imperfect performance, which is reasonably common in rats. However, many of those rats which achieved criterion without oscillation performed five consecutive avoidance responses. Several attained criterion and continued thereafter on an uninterrupted sequence of avoidance responses during at least 40 extinction training trials. Nevertheless, some rats may have achieved the 5/6 criterion without "knowing" the shuttle task.

Because the 5/6 criterion had proved inconvenient, we switched to 5/5 after the second experiment (1966b). In several experiments since then, 54 normal rats have been trained to the new criterion using similar US intensities and identical procedures to those used earlier. Moreover, 38 of these rats have been given 40 extinction training trials beginning on the day following criterion attainment. To compare acquisition to a 5/6, 5/5, and a 7/7 performance criterion (the last two trials for this last criterion come one day after attainment of the 5/5 criterion, during extinction training), the data were treated identically and tested for nonincrementality by χ^2 . Table 1 summarizes the performance of the 49 rats which attained the 5/6 and 5/5 performance levels, and of 33 rats which could be tested at a 7/7 criterion. (Sixteen of the 54 Ss were given no extinction training; two rats which reached the 5/5 criterion did not attain the 7/7 criterion.)

The data were all-or-none at all three criterion levels. Errors increased slowly and oscillation sequence length more rapidly with more stringent criterion. Those rats which did not oscillate were not included in the oscillation analysis. These Ss achieved

criterion in a mean of 2.89 trials (5/6, n=9), 3.89 trials (5/5, n=9), and 3.00 trials (7/7, n=3).

Pearson correlation coefficients between Total Errors and Trials to Criterion for each criterion were determined. These were $r_{5/6}=+.93$, $\sigma_r=.016$; $r_{5/5}=+.87$, $\sigma_r=.035$; $r_{7/7}=+.84$, $\sigma_r=.05$. It must be concluded on the basis of these data that acquisition of an air-blast-motivated avoidance response by rats to performance levels of up to seven consecutive correct responses is an all-or-none, not a gradual process.

A final point should be raised. Why did the squirrel monkeys take so long to acquire the response? Could the oscillation sequence length have been reduced? I think so. First, a compound CS has been shown to be a more effective CS than a light CS (McAllister & McAllister, 1965), and using a buzzer-light combination (buzzer CS is better than tone, Myers, 1962) would probably reduce trials to criterion. Second, 100 psi air pressure is extremely high; monkeys find 12 psi aversive (Masserman & Pechtel, 1953), and both cats and rats respond energetically to 25 psi (Ray, 1966c, d). Under these circumstances the S is likely to be nearly as emotional as when it is shocked. The high degree of emotional arousal usually associated with shock-motivated shuttle-avoidance learning is probably responsible for the observed slow rate of acquisition (Ray & Lenz, in press). A better CS and a less intense US would, I believe, result in more rapid acquisition by the squirrel monkeys. It is then likely that this acquisition, lacking most or all of the oscillation sequence, would be nonincremental.

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