Performance Speed as a Function of Practice Speed

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In a paired-associate learning task, one group was instructed to practice fast and the other instructed to practice slowly, everything else being held constant. When each S reached a set criterion of learning, he was tested under instructions to perform as rapidly as possible. The fast-practice group performed at a significantly faster rate than the slow-practice group.

The effectiveness, and indeed, even the existence of speed reading and typing courses provide heuristic evidence that speed of response is learned (Logan, 1963). For example, although reading is a highly practiced response, it is typically performed at a fairly constant, relatively slow rate. With forced fast practice, however, reading speed can be significantly increased. The present experiment was designed to test the hypothesis that an important determinant of performance speed in laboratory paired-associate learning is practice speed; that a rate of response is in this sense learned.

This effect is a direct prediction of the micromolar approach to learning theory (Logan, 1956, 1963). Micromolar theory views speed not as a measure of the strength to which a response has been learned, but as a defining property of different responses. In this view, a fast response and a slow response are taken to be two different responses, capable of being differentially reinforced; response speed is learned as a function of practice speed. Micromolar theory becomes especially useful when the only grossly observable difference in response is that of speed, as might be the case, for example, with fast and slow reading or paired-associate responding.

Micromolar considerations give rise to important implications for many areas of education. It is apparent that most endeavors have an optimum speed at which they should be performed. This optimum speed may be as fast as possible, as in the cases of typing or reading, or intermediate, as in the case of speechmaking. Frequently, however, behaviors are not taught with their optimal speed in mind. In many cases the speed factor is largely ignored as when an arithmetic teacher slows down the pupils in order to reduce their error rate. This is not to say that responses should always be taught at their desired optimum speeds; in fact, since the difficulty of performing most responses increases with speed, initial slow practice is often essential. It is to say, however, that optimum speed must ultimately be taught if it is to be learned. The answer lies in finding the teaching schedule that reaches the optimum speed and accuracy with the least amount of time and effort.

The present experiment was designed to see whether it is indeed the case that rate of response is affected by the rate at which Ss are instructed to practice. If so, there would be empirical justification for a series

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of studies to evaluate the implications of this effect in an educational setting.

**Method**

**Subjects.** Twenty-three unpaid male Ss from the introductory psychology course at Yale University were divided randomly into two groups of 12 and 11 members each. They were run individually in 1-hour sessions over a period of 4 days. Two months later all the Ss were recalled without advance notice for a second 1-hour individual session.

**Apparatus.** The S sat facing a rectangular display of 60 lights in 6 rows of 10 lights each. Directly above this display was a small speaker and above the speaker was a row of 11 Dialco indicator lights, numbered from 0 to 10. Preselected patterns of lights on the display were used as stimuli and the associated response numbers were illuminated by an indicator light. A throat microphone timed the verbal responses and produced a change in the stimulus pattern in the testing portion of the experiment. The S sat in semi-darkness; the control apparatus and E were behind a large partition. Four timers accurately controlled the intervals used during training. The timers played no part during testing, each pattern being replaced immediately by the next pattern as rapidly as S responded.

**Procedure.** The Ss were seated and given highly motivating instructions by mentioning correlation of performance on this task with intelligence. They were then told they would see a pattern of lights, followed by a buzzer, followed by an answer light, followed by a short wait before the next pattern presentation. They were instructed to learn which numbers went with which patterns and to respond, guessing if necessary, the moment the buzzer sounded. There was no mention of a testing sequence to follow (although, in the second session, Ss probably anticipated the speed test).

In the first session of the experiment, 7 patterns were used, consisting of 8 randomly chosen lights with no light in more than 1 pattern. The patterns were presented in 7 random groups of 7 before repeating, with the restriction that no pattern appeared twice in succession.

All Ss practiced with the same time intervals except that the fast group heard the buzzer 0.75 sec after they saw the pattern while the slow group heard the buzzer 2.25 sec after seeing the pattern. That is, the only difference between the groups was that the slow group practiced answering 2.25 sec after seeing the stimulus, while the fast group practiced answering 0.75 sec after seeing the stimulus. This is illustrated in Fig. 1. As is shown, the total time for each pattern was 7.0 sec, of which 1.5 sec were empty.

After S had got 50 out of 52 consecutive patterns correct, it was explained that the task was changed and that he was to try to get as many patterns correct as he could in 2 min under a procedure such that each time he gave an answer, the next pattern would immediately appear. After this test period, the S was given paper with drawings of the 60-light array on it and was asked to circle the key lights that he used to identify each pattern.

The second session, two months later, was basically identical to the first, except that the fast group was now run in the slow condition and vice versa. The patterns and answers were changed, there being 6 patterns in this session, each pattern containing about twice as many lights as in the first session and with each light a member of 2 patterns.

**Results and Discussion**

It is reasonable to expect that the fast-practice condition is the more difficult, and would require more training to meet the performance criterion. In fact, there was no difference in number of trials to criterion in the first session (see Table 1), but there was a difference ($p < .05$) in the second session. Since the within-group correlations in trials to criterion in the two sessions were .84 and .88, this score provides a highly consistent measure of individual ability to learn in this task and suggests that the groups differed in learning ability, with the one group first learning the more difficult task as quickly, and then learning the easier slow task more quickly than the other.

In spite of possible differences in learning ability, in both the first and the second sessions the groups that practiced faster made significantly more correct responses during the test ($t = 2.3, p < .05$ for the first session; $t = 3.2, p < .01$ for the second
session). Furthermore, combining the groups and ignoring order, the Ss made an average of 12.4 more correct responses during the test following their fast learning condition than following their slow learning condition \((t = 5.0, p < .001)\). None of the results would be appreciably changed if total number of responses rather than total number of correct responses were used as a measure of response speed. The number of correct responses made by each group during 2 min of free responding is shown in Table 1. It should be recalled that the same Ss learned under opposite conditions in the two sessions and noted that their resulting performance levels shifted accordingly.

The micromolar explanation of these results states that the Ss have learned best to respond at the speed at which they practiced, that there would be some generalization to faster speeds, but that the slow-practice group would be less able to respond rapidly. That is to say, because the test condition required a more drastic shift for the slow-practice Ss, they should have suffered a greater generalization decrement. Presumably, a reverse difference should be demonstrable if the test conditions required slow responding since the fast-practice Ss would know best how to respond rapidly. The value of this position depends on the fact that both groups learned the answers equally well. The use of a learning criterion before testing was intended to insure this equality, and other possibly important factors such as intertrial interval and total exposure time were equated.

Nevertheless, if the Ss who practiced fast did require more training, they could have, in some sense, learned the task better, and it was reported above that the fast condition probably was more difficult. To promote this argument further into an alternative account of the results, it would be necessary to show that the number of trials to criterion is an important determinant of test performance. Quite the opposite was found to be the case within groups (the correlations for each group in each session were \(-.26, -.68, -.58\) and \(-.77\)) the faster learners being the better test performers, but it is still possible that the reverse relationship could hold between groups. There is a bit more indirect evidence tending to dispute this, however. All Ss at the conclusion of the second session were given 35 additional training trials in the fast condition and then retested for response speed. The mean response speeds found for the two groups were almost the same (fast, 105.2; slow, 103.2) indicating that the groups were equivalent if given the same fast training. In any case, the micromolar prediction is that additional training under the slow condition would only further solidify the slow speeds being learned, and reduce subsequent test performance, whereas the alternative analysis would predict that additional slow training would improve subsequent test performance; hence, a relatively straightforward test of these alternatives can be run.

The micromolar approach implies that slow-practice Ss will make more errors when trying to perform fast, although the fact that the present procedure allowed them to pace themselves rather than forcing them to respond at a prescribed fast pace makes this expectation somewhat tenuous. There was no difference in this regard during the first session (2.6 and 2.7 errors by the slow and fast groups, respectively), but there was a difference in the expected direction during the second session (2.9 and 2.0 errors by the slow and fast groups, respectively, \(p < .05\)). The lack of a difference in the first ses-

<table>
<thead>
<tr>
<th>Session</th>
<th>Group</th>
<th>Mean trials to criterion</th>
<th>Mean correct in 2 min</th>
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</thead>
<tbody>
<tr>
<td>1st</td>
<td>Slow</td>
<td>137</td>
<td>90.1</td>
</tr>
<tr>
<td></td>
<td>Fast</td>
<td>139</td>
<td>103.1</td>
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<tr>
<td>2nd</td>
<td>Slow</td>
<td>88</td>
<td>88.3</td>
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<tr>
<td></td>
<td>Fast</td>
<td>112</td>
<td>99.1</td>
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tion was due to the performance of two Ss in the fast-practice condition who were in obvious atypical mental and physical condition at that time and who committed more than half the mistakes of their group. Hence it is believed that the results tend to support the prediction and indicate that Ss who practice at a slow rate may have difficulty in performing at a substantially faster rate. Whether this principle would apply equally to transfer from fast practice to slow performance remains to be tested.

Looking at the results from a more molecular point of view, it is possible that the fast Ss learned a more efficient way to discriminate the stimulus patterns in the display. Although quite distinct methods of solution were used by the Ss, their drawings of their methods revealed no discernible difference between groups. Of course it is possible that other, more molecular, methods than those looked at could be different for the two groups.

A related, more testable hypothesis is that positive learning did not differ between the groups, but that the slow group developed greater inhibition of very fast responses. That is to say, the slow Ss might think of the answers as rapidly as the fast Ss, but having learned to inhibit saying them during training, would have difficulty overcoming this inhibition during testing. It was felt that a verbal response, rather than a selective motor response, would be less susceptible to this interpretation, because adult humans have had extensive practice getting their thoughts into words. Nevertheless, it would be desirable to test this analysis by devising procedures involving less potential inhibitory factors.

In addition to the lines of work already indicated, it will be important to study retention following fast and slow practice, to evaluate possible adjusting practice schedules that begin with slow practice, but become fast through programmed stages, and to determine whether Ss can differentiate speeds of different associations within the same total task. From a practical point of view, it is important to assess practice speed in relation to total learning time in view of Bugelski's (1962) finding that trials to criterion varies with exposure rate so as to keep time to criterion constant, and because fast practice trials could be given at a faster rate than slow ones.

References


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