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The Problem of Controlling Level of Learning in Studies of Associative Interference in Psychomotor Performance

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The problems discussed in this paper arose during a search for an experimental design that would yield reliable measures of associative interference for the individual subject. Such measures are needed as part of an extensive research project concerned with individual susceptibility to interference in verbal and psychomotor performance.

Interference effects are commonly studied in the laboratory under conditions that provide for original learning (OL) of some task to a given criterion, interpolated learning (IL) of a different task to a given criterion, and the subsequent relearning (RL) or recall of the original task. Two measures of interference are sought when this design is employed: (1) the retardation in the learning of the interpolated task resulting from the previous learning of the original task (associative inhibition), and (2) the decrement in the recall of the original task arising from the learning of the interpolated task (retroactive inhibition). A control condition is included to reveal the effects of rest periods (passage of time) inserted between the learning of the original task and its later recall.

Most of the detailed knowledge of interference has come from laboratory studies involving the learning and retention of paired associates (pairs of words, nonsense syllables, etc.). Melton (*1*) and McGeoch (*2*), in studies aimed at determining the variables contributing to interference in verbal learning, have shown that the level of OL and the level of IL are critical factors. Therefore, in any study of interference phenomena, level of learning should be as precisely controlled as possible. An inadequate control of level of learning during OL or IL makes an interpretation of the amount of interference difficult and may lead to misleading generalizations.

There are three common criteria of level of learning in paired-associates (verbal) learning: (1) Each subject learns equal amounts of the material. The criterion is a certain number of correct anticipations out of N possible anticipations. If, for example, a list of eight word-pairs is employed, the criterion for each subject may be the correct anticipation of five (or more) word-pairs on some trial. (2) Each subject has equal opportunity to learn. With this procedure, the number of trials is held constant for all subjects. (3) Each subject is brought to a given level of performance on each word-pair. This is the Adjusted Learning Method where the criterion is a given number of correct anticipations of each word-pair by each subject. When the criterion is attained, the word-pair is withdrawn from the list to preclude the possibility of over-learning.

The learning of equal amounts of the material and giving equal opportunity to learn are standard criteria employed with the memory drum. The construction of the memory drum, however, does not permit the use of the adjusted-learning technique since it is not possible to remove a word-pair from the list after it has been learned to the performance criterion. Apparatus specially constructed for use with this method is necessary. Space does not permit a summary of the evidence showing that the adjusted-learning technique is superior to typical memory-drum techniques in controlling level of learning in paired-associates learning.

Motor learning differs characteristically from verbal learning, as the latter occurs in the laboratory. The amount and kind of verbal material is usually well within the ability of most subjects to master. For example, if 12 word pairs constitute the list to be learned, the average subject can correctly anticipate seven response words after seven or eight trials. Subjects are not fully taxed in such a situation and perform far below their performance asymptote. In contrast, practice on equipment such as the Mashburn apparatus (described elsewhere, *3*), may continue for indefinite periods of time, and achievement may eventually approach the physiological limit. Because it is not feasible to employ a criterion of complete mastery in most motor tasks, the problem arises as to how to evaluate the various levels of learning attained by different subjects under particular experimental conditions.

The usual procedure in motor learning is to run each subject a fixed number of trials and assume that the relative level of learning is equal for all members of the group since each has been given equal opportunity to learn. This ignores the initial performance level of the subject and his rate of improvement in performance, both of which operates to bring the subjects to different levels of performance after a given number of trials. Nor can the likelihood of each subject's approaching a different performance asymptote be overlooked in the evaluation of individual learning curves.

An alternate possibility, comparable to the method of adjusted learning in verbal studies, is to bring each subject to a common level of performance. This tacitly assumes that the level of learning is equal when each subject is making the same number of correct responses regardless of the number of trials taken to attain this level. However, it cannot be denied that each subject has a different initial performance level, a different rate of learning, and may well approach a different performance asymptote. A disadvantage of a fixed performance criterion is the necessity of using the Vincent technique to combine individual curves based on differing numbers of trials. But the most serious difficulty that arises if each subject is brought to a common performance level is that the chosen level may be close to the performance limit for one individual and far below the limit for another.

Figure 1 graphically illustrates the problems involved in using the number of trials and performance level as criteria. The curves are based on the performance of three male subjects on the Mashburn apparatus. Each subject came to the laboratory for a half-hour period each day for 15 consecutive days. Ten two-minute

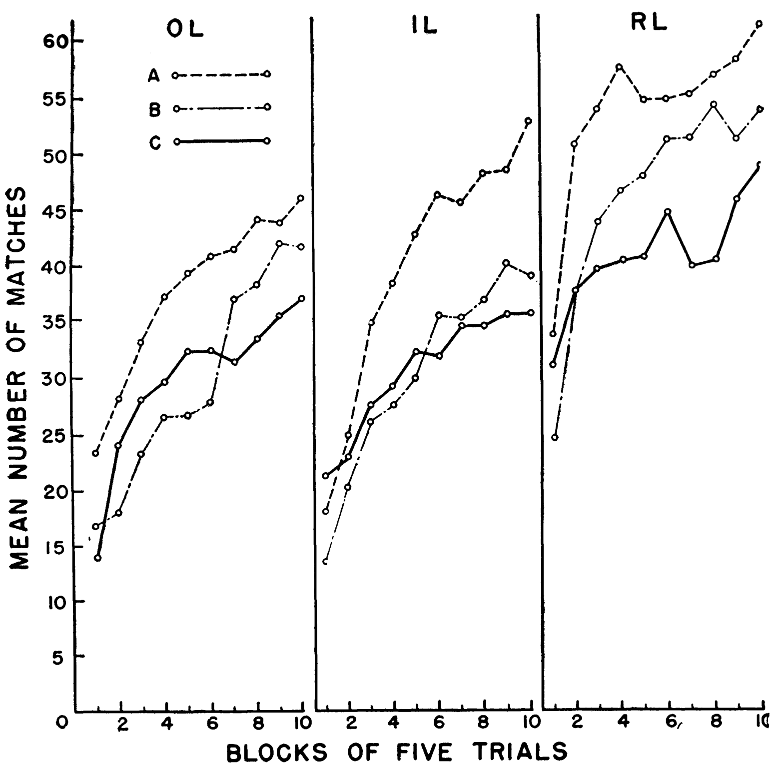

Figure I

trails were given each day, with a 15-second rest period between all trials, except 5 and 6, where a two-minute rest period was given. The score obtained by a subject was the number of matches made per trial. All subjects were given 50 trials of OL, 50 of IL, and 50 of RL. As seen in the figure, the subjects attained different levels of performance when given an equal opportunity (an equal number of trials) to learn. Each subject began at a different level and had a different rate of improvement. The extrapolation of these curves would show each approaching a different performance asymptote. Comparable difficulties would have arisen if the subjects had practiced until each had attained some common level of performance — say 35 matches. In OL, Subject A had a rapid rate of learning and, at 35 matches, had probably achieved a far different proportion of his performance potential than Subject C. Similar differences appear in IL and RL.

The use of either of the two described procedures in attempting to equate level of learning among individual subjects may lead to erroneous conclusions. If either criterion is used in studies of associative interference, the amount of decrement displayed by a subject at the outset of relearning may be as much an index of level of learning as of individual susceptibility to interference; and any decrement that is obtained might be different from the one that would have occurred if level of learning had been more adequately controlled.

A satisfactory solution of the problem of controlling level of learning on a psychomotor task is by no means simple. To surmount the shortcomings of the other methods we will consider level of learning most adequately controlled when each individual has attained the same relative level with respect to his own learning potential. This level would be one-third or one-half or some other part of the individual's total potential ability to perform. Using this criterion it would be necessary to give each subject a fixed number of trials on, say the Mashburn apparatus, fit a curve to the resulting scores, and then extrapolate to obtain an estimate of his performance asymptote. Each subject could then be given the number of practice trials required to reach the predetermined level with respect to this predicted asymptote. The determination of this level would be made upon the assumption of equal units of measurement at points of the learning curve. Level of learning could now be regarded as more nearly equal because each subject would have attained the same relative level with respect to his own performance asymptote. If a group curve were desired the Vincent technique would have to be employed to combine the individual curves where each would have a different number of trials in attaining the criterion.

This procedure would, of course, only be applicable to tasks such as the Mashburn apparatus where the limit of performance is a function of the individual's ability. It would not be feasible on equipment such as the Two-Hand Coordinator where the limit is imposed by the nature of the apparatus and is capable of attainment by most if not all of the subjects. In this respect the Two-Hand Coordinator is similar to verbal learning where the criterion is far below the performance asymptote. It can be tentatively suggested that a procedure analogous to the method of adjusted learning in verbal studies where all subjects achieve a common performance level may be the most satisfactory.

The somewhat laborious, but nevertheless more inclusive, procedure outlined for controlling level of learning in motor apparatus of the Mashburn type, has advantages over the other methods discussed in that it encompasses variations in individual learning curves. Although this plan is as yet in the programmatic stage, the obvious shortcomings of the other procedures strongly suggest that an approach of this kind will prove more fruitful in controlling the level of learning variable in studies of psychomotor performance.

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