THE EFFECTS OF PRACTICE ON INDIVIDUAL DIFFERENCES.

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The general problem. There is, perhaps, no question of greater significance both to psychological theory and to educational theory than the question, How does training affect individual differences among people? That individuals differ widely in the various traits with which education is concerned is a well-known fact; and it is probably no exaggeration to say that it is the most important and the most difficult problem in education at present to determine how proper provisions for these differences may be made. In our attempts to deal with this problem, our thinking is necessarily influenced greatly by our views concerning the essential cause of these differences and the manner in which, and the extent to which, they are affected by training.

Opposed views concerning the effects of practice on individual differences. Educational literature presents two diametrically opposed views concerning the primary cause of individual differences and the manner in which equal amounts of training affect these differences. The prevalent view, supported by many of the most eminent educational phychologists, is that differences among individuals are due in a larger degree to nature than to nurture and that equal amounts of training therefore increase these differences. The following quotation from Thorndike[1] will serve to set forth this view:

"In so far as the differences are due to differences in the quantity and quality of training which they have had in the function in question, the provision of equal amounts of the same sort of training for all individuals in the group should act to *reduce* the differences * * *. If the addition of equal amounts of practice does *not* reduce the differences found amongst men, those differences can not well be explained to any large extent by supposing them to have been due to corresponding differences in amount of previous practice. If, that is, inequalities in achievement are not reduced by equalizing practice, they cannot well have been caused by inequalities in previous practice. If differences in opportunity cause the differences men display, making

[1] Thorndike, E. L. Educational Psychology, Vol. III. New York: Teachers College, Columbia University, 1914, pp. 304-305.

opportunity more nearly equal for all by adding equal amounts to it in each case should make the differences less.

"The facts found are rather startling. Equalizing practice *seems to increase differences.* The superior man seems to have got his present superiority by his own nature rather than by superior advantages of the past, since, during a period of equal advantages for all, he increases his lead."

Among others who have expressed similar views may be mentioned Terman, Starch, Dearborn, Henmon, and Gates. Not all students of the problem, however, agree with the view set forth above. Some maintain that differences in achievement among people—at least in many types of performance—are primarily due to differences in training and that consequently equalizing opportunities for improvement tends to reduce these differences. Bagley, for example, says[2]:

"The present paper will * * * include a reference to the related studies which have now thoroughly discredited the determinists' contention that individual differences are inevitably widened by training—the investigations which prove that education, under certain conditions at least, actually operates as a 'leveling-up' agency."

Difficulties encountered in an experimental investigation of the effects of practice on initial differences. The fact that numerous experimental studies of the question have failed to result in a generally accepted answer suggests that an experimental attack upon the problem is attended with serious difficulties that render a conclusive answer almost, if not quite, unobtainable. One who examines the available evidence afforded by the various studies of the problem can hardly avoid the suspicion that many of the investigators were not clearly conscious of the difficulties involved. It is the main purpose of this paper to suggest some of the most troublesome questions which the experimental investigator of problem must face. These may be grouped under four headings as follows: (1) Determining equal amounts of practice; (2) Securing satisfactory measures of ability at various levels of practice; (3) Measuring individual gains; and (4) Comparing individual gains. These will be discused in order, though in the brief time allowed it will be possible only to suggest the major difficulties without any extensive elaboration or any discussion of the most promising means of obviating them.

[2] Bagley, W. C. Determinism in Education. Baltimore: Warwick and York, Inc., 1925, p. 133.

I. Determining Equal Amounts of Practice.

The difficulty involved in measuring practice. Practice in a given function consists in the exercise of neural connection that are useful in that function and also in the inhibition and elimination of useless and harmful connections. We are not able to apply a defined unit of neural activity to a given performance and thus measure directly the amount of practice received by the learner. We are therefore forced to resort to indirect measurement with the aid of any unit which can be employed, thus obtaining a measure which is valid only to the degree that the relationship between the neural activity and the unit employed is constant or varies in a known manner.

Measurement of practice in time units. Thorndike advocates the measurement of practice in time units. This recommendation has the obvious merits that the units are clearly defined, familiar, and readily applicable to practice in all functions. Thus one knows, at least in one sense, exactly what is meant by ten minutes of practice in multiplying one three-place number by another or in substituting digits for symbols. If one wished to compare rates of improvement in different functions, doubtless it would be advisable to measure the practice in time units.

It cannot be maintained, however, that practice in a given function for a given length of time is exactly equal practice for all persons. Thus the person who can multiply one three-place number by another correctly in thirty seconds will receive, in terms of exercise of useful connections, more practice in this function in ten minutes than will the person who requires two minutes for each example.

Measurement in work units. Practice may also be measured in terms of the number of units of work performed, regardless of the different lengths of time required by different subjects in completing the work. It is probable, however, that such amounts of practice are not truly equal for all learners, since the less proficient subject likely receives more practice in the sense of inhibiting or eliminating undesirable neural connections than does the more capable subject.

Conclusion. We do not know what constitutes exactly equal practice for all learners. Instead of inquiring how *equal amounts* of practice affect individual differences, we can only inquire how practice for *equal lengths of time,* or practice involv-

ing the performance of *equal amounts of work,* affect these differences.

II. Securing Satisfactory Measures of Ability.

Fluctuations in measures of ability. Ability may be defined as a state or degree of readiness-to-act on the part of the individual, primarily of the individual's nervous system. It, therefore, can not be measured directly, but is to be described only in terms of performance. Since ability can be known only through performance, the latter is measured and the assumption made that, as ability varies, so will performance. Monroe says[3]: "It is assumed that the performance sustains a constant functional relation to the ability which is being measured * * *. This assumption means that any change in ability from pupil to pupil produces a proportional change in the performances, and that all variations in performances are produced by corresponding changes in ability."

The writer just quoted points out[4] that the assumed constant functional relation between ability and performance is never realized, consequently errors are introduced if the scores obtained are taken as measures of ability. He is therefore led to distinguish between the ability which is assumed and the ability which is measured[5]:

"In this connection it is, perhaps, helpful to distinguish between the ability a pupil possesses but may not exercise completely because he makes little effort, and the ability which functions in the production of the performance. The former we may call his *potential ability.* The ability which is active is his *kinetic ability.* This is what we measure."

The term "ability" appears to be used usually in the sense of "potential ability", i. e., the total resources of the individual upon which he can, and will, draw in a given performance provided all the factors influencing the performance operate as favorably as possible in the direction of the utilization of all available resources. Such a state of affairs, however, rarely or never exists, and if it did it probably could not be recognized as such. Hence we can not, in general, measure "potential ability".

"Kinetic ability", however, is much more easily measured with a fair degree of accuracy, at least in many types of per-

[3] Monroe, Walter S. An Introduction to the Theory of Educational Measurements. Boston: Houghton Mifflin Company, 1923, p. 22.
[4] Ibid. p. 24.
[5] Ibid. p. 193.

formances. Hence it appears to be a somewhat more useful concept in studying the effects of practice than does the concept "potential ability." Since we have defined ability under a given set of conditions as a readiness-to-act resulting from the combined influence of all the factors involved, we may then assume a constant functional relation between this readiness-to-act and the resulting performance.

This definition of ability relieves us, in a large measure, from the necessity of considering the troublesome factor of unreliability of the obtained scores as measures of ability. On the other hand, it forces us to think of ability in a given function, even apart from changes due to practice, as a very unstable trait, since it fluctuates with every change in the combination of factors producing it.

Defects in measuring instruments. A more serious difficulty is found in the defects of the measuring instruments employed to determine the status of the learner before and after practice. In general, the zero points of these instruments are not clearly defined, nor are the different units of any scale known to be equal. It follows that a score, say, of four does not usually mean twice as much ability as that represented by a score of two, nor does a gain from a score of five to a score of ten necessarily represent the same amount of improvement as does a gain from the latter to a score of fifteen. In other words, the lack of defined zero points invalidates the ratio method of comparing gains and the inequality of units introduces errors into taking differences between initial and final scores.

III. Measuring Individual Gains.

Numerous possible procedures. If one lists all the different methods that have been employed in measuring the gain made by an individual during practice, one will find a total number that will probably be surprisingly large. The writer has found forty-one different ways of expressing individual gains, all of which may be useful, at least in certain cases, and no one of which is faultless. He has also found at least twelve different methods by which these gains have been treated in order to determine the effects of practice on initial differences. With a few exceptions, each of the forty-one measures of individual gains may be treated by any of the twelve methods of measuring the effects of the training. At least, there are more than three hundred fifty pos-

sible ways of treating the raw scores in order to ascertain the effects of practice, no two of which will, except by chance, yield identical results. It is not surprising, therefore, that investigators of the question do not agree in their conclusions.

Among the questions at issue in deciding upon the proper method of expressing the gains made by individuals during practice, the following may be mentioned: (1) Shall gain be taken from the initial score to the final score, or from the initial score to the best score, or from the average of several early scores to the average of several late scores? (2) Shall efficiency—and hence gain—be measured in units of work-per-unit-time or in units of time-per-unit-work? (3) Shall gain be expressed as gross gain or as percentile gain?

We can not here undertake to answer any of these questions, further than to say that, since no one procedure is demonstrably superior in all cases, it appears that several of the better procedures should be employed and the results of all taken into consideration in arriving at final conclusions.

IV. Comparison of Individual Gains.

Various possible procedures. Having determined, by several different methods, the gain made by each learner during practice, the investigator then faces the question, How should these various sets of measures of gain be treated in order that the effects of the practice on individual differences may be ascertained? It has already been stated that at least twelve different procedures are possible, no one of which is wholly satisfactory and no two of which are certain to point toward the same final conclusion. If time permitted, it could be shown that some of these methods often lead to erroneous conclusions, while others—particularly when they point to the same general conclusion—are fairly reliable. Without attempting here any defense of his choice, the writer believes that all of the following procedures should be employed and the results of all considered in interpreting the data:

(1) Computing the average gross gains of the highest and lowest quartiles or tertiles;

(2) Computing the average percentile gains of these groups;

(3) Correlating initial scores and gross gains;

(4) Correlating initial scores and percentile gains;

(5) Computing coefficients of variability at the beginning and end of practice;

(6) Observing the trends during practice of a number of ratios of the series, best/worst, second best/second worst, and so on.

One further difficulty. We may sum up the difficulties thus far mentioned by saying, with no high degree of exaggeration: (1) We do not know what constitutes equal practice; (2) we could not measure its effects if we did know; and (3) we should not know what to do with the measures if we had them. To these three discouraging statements, we may add another, if we accept the view, which is generally held, that a given gain in score denotes a greater amount of improvement if made along the upper portion of the practice curve than if it occurs along the lower portion—namely, we should not know what the results meant, even if we had accurate measures of ability at the beginning and end of training and knew what statistical treatment to apply to them. It appears, therefore, that the ambitious researcher who sets out to investigate the effects of practice on individual differences need not fear that he will find himself engaged in a task that does not call into action all of his talents and powers.

Present status of the problem. Had it been possible to do so adequately in the brief time allotted to this paper, the writer would have preferred to consider the experimental evidence available on the question. He can not refrain, however, from remarking that, in his judgment, this body of evidence has frequently been misinterpreted. A careful consideration of the procedures followed in many of these investigations reveals that —not to mention other defects—the statistical treatment applied to the data has not been wisely chosen. As a consequence, the investigator has often arrived at unjustifiable conclusions.

The writer has examined thirty-one studies, in twenty-seven of which the investigators were either primarily concerned with the problem of the effects of practice on individual differences, or at least sufficiently interested in the question to interpret their data with reference to it. In four of the thirty-one studies, no mention of the problem occurred, but the raw scores have been analyzed by the writer for any light they might throw on the problem. Furthermore, in the twenty-seven studies in which the problem was considered, the present writer subjected the raw

scores, when reported, to a more careful analysis than the original investigators, and often arrived at conclusions that differed from theirs.

It is true that the original investigators concluded more often than otherwise that practice increases differences. The present writer, however, reached the opposite conclusion. If we consider all the different functions that were practiced, counting each as many times as training was given in it, by different investigators or by the same investigator with different groups, the original investigators concluded as follows: In the case of forty-four functions, training increased the differences; with twenty-two functions the opposite was true; and in eight cases the effects of the training were uncertain.

If to these seventy-four functions are added nine others, the effects of the training in which are not stated by the original investigators, the present writer's interpretation is: In eight cases practice increased the initial differences; in thirty-nine cases the result was the contrary; and in thirty-six cases the effects of the training on initial differences were slight or uncertain.

In closing, it may be said that the writer has, during the past two years, conducted three rather careful and elaborate investigations of the problem, and reached about the same conclusions from his data as he did from those of previous studies; that is, in the case of a majority, though not all, of the functions practiced, the training seemed to reduce initial differences among the learners.

In the light of the conclusions reached by a careful evaluation of the evidence afforded by earlier studies of the problem, as well as that obtained in his own investigations, the writer believes that the prevalent view in educational psychology to the effect that training increases individual differences is not in harmony with the experimental evidence.