UNIVERSITY OF PENNSYLVANIA

THE WITMER CYLINDER TEST

BY

FRANKLIN CRESSEY PASCHAL

A THESIS

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

PHILADELPHIA:
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I

INTRODUCTION

The differential diagnosis of the psychological clinic requires a variety of "behavior" tests, tests which give the child something to do, which place in his hands an article that to him is a thing to play with, in order that his actions may be observed,—that we may, so to speak, see his mind in action. The reactions to the situations arising bring out qualitative differences in the normal and feeble-minded groups, as well as between the various other types. A diagnosis would be of little value in most cases were it not accompanied by suggestions of treatment, but treatment cannot be recommended without a thorough knowledge of the mental make-up of the individual, the strength and weakness of the various mental traits, and an acquaintance with the special defects that may be present and of any particular adaptabilities that the individual may have.

Healy and Fernald (2) in presenting their tests, remark that, "Diagnosis of mental capabilities and adaptabilities as far as this might be practically possible, was seen at the outset of the work of the Juvenile Psychopathic Institute to be one of the main desiderata in our study of individuals who are young members of the criminalistic class or who are otherwise repeatedly delinquent." For such work as this, a scale of intelligence tests alone is not sufficient. The study of the perceptions, of the ability to profit by experience, coordination, of psycho-motor ability, as Wallin (13) calls it, demands some sort of clinical material that will permit the study of behavior. To quote Stern (11), "We must, of course, guard against the danger which is apt to arise of supposing that we have grasped the individuality of a pupil in its totality, when we have tested his intelligence." Wallin called attention to the need of a graded scale of "motor diagnostic tests" which would give a differential age determination of what a normal boy or girl could do industrially, or in motor performance.

Wooley and Fischer (17), in speaking of the low correlation between school grade and performance with the puzzle box, call attention to the fact that such a low correlation with the test requiring "a more original mental procedure" than that of any other test they used, suggests that the school is failing to recognize certain important forms of ability.

Another work illustrating the need of such tests is that of Stenquist, Thorndike and Trabue (10), who in the mental examination of dependent children found that they were inferior to normal children in their mechanical test, though not so much so as in the more abstract abilities. Any proper estimate of these children, then, should take the former as well as the latter into consideration.

It was in response to such a demand that the formboard came into clinical use, the picture puzzle tests, the Knox Moron test, the Healy Instruction Box, Puzzle Box, as well as a wide variety of other tests.

More recently, as a result of the inadequacy of the Binet Scale in the examination of deaf children, Pintner and Patterson (8) have prepared a scale of performance tests which they have standardized and believe will serve as a supplement to the Binet Scale, being a corrective where language ability is rated too high. They have pointed out that tests dependent upon the reception of complex instructions, the comprehension of verbal directions, or in which the response requires the ability to use language, places even the feeble-minded "verbalist," described by Healy (3) at an advantage as compared with the deaf child. Though we are not to consider the latter to be equal to the normal child, it must be noted that his defects are confined to certain traits and others must be examined without relation to those.

Whenever language difficulty is present, from use of a foreign tongue in the home or the lack of educational advantages as well as from the special defects, recourse must be had to performance tests. Place a piece of apparatus before the subject and ask him by signs to do something. His ability to comprehend is an indication of his intelligence; his performance with the material when once it is understood, can be compared with the results of normal individuals of the same age.

Such a test is the formboard, which has probably been the most popular single performance test. In the Psychological Clinic of

the University of Pennsylvania, it has received considerable attention, a standardization having been made by Sylvester (12) and another of a revised form of the board by Young (19). But while the test gave an age gradation up to the fourteenth year, it did not present a real problem to be solved beyond the sixth year. From that age onward, it was concluded that any normal child could do the test in a comparatively short time, the speed of accomplishment varying with mental development and with the development of certain traits. But a more difficult piece of apparatus was needed, something that would in nature approximate the formboard. In the search for a test of this kind, Professor Lightner Witmer was attracted by statements of Dr. Montessori regarding certain pieces of her didactic material.

Under the heading "Sensory Education," Dr. Montessori (6) presents first, "Three solid pieces of wood, in each of which is inserted a row of ten small cylinders, or sometimes disks, all furnished with a button for a handle. In the first case, there is a row of cylinders of the same height, but with a diameter which decreases from thick to thin. In the second, there are cylinders which decrease in all dimensions, and so are either larger or smaller but always of the same shape. Lastly, in the third case, the cylinders have the same diameter but vary in height, so that, as the size decreases, the cylinder gradually becomes a disk in form. The first cylinders vary in two dimensions (the section); the second in all three dimensions; the third in one dimension (height). The order which I have given refers to the degree of *ease* with which the child performs the exercises."

This exercise, which is the one she prefers for children of two and a half to three years of age, consists in returning the blocks to their recesses after they have been removed and mixed on the table. In a discussion of her method, Dr. Montessori (7) states that this material shows a "difference in the reaction between deficient and normal children, in the presentation of didactic material made up of graded stimuli. This difference is plainly seen from the fact that the same didactic material used with deficients *makes education possible*, while with normal children it *provokes auto-education*."

This set of didactic apparatus promised to be of use as a mental test as it possessed these requisite qualities:

First: A qualitative difference in performance. Dr. Montessori gives a description of the performance of a normal child and brings out a number of points of diagnostic importance, such as profiting by experience, spontaneous interest, evidence of perplexity when face to face with an error, as contrasted with the indifference and inability to correct errors on the part of the deficient child.

Second: A series of graded stimuli, which may be presented in order of ease of performance.

Third: Applicability to a wide age range, with increasing performance with age. While its use as didactic material is limited to the ages of two to four, it was to be expected that with increasing age there would be increased ability to solve this problem.

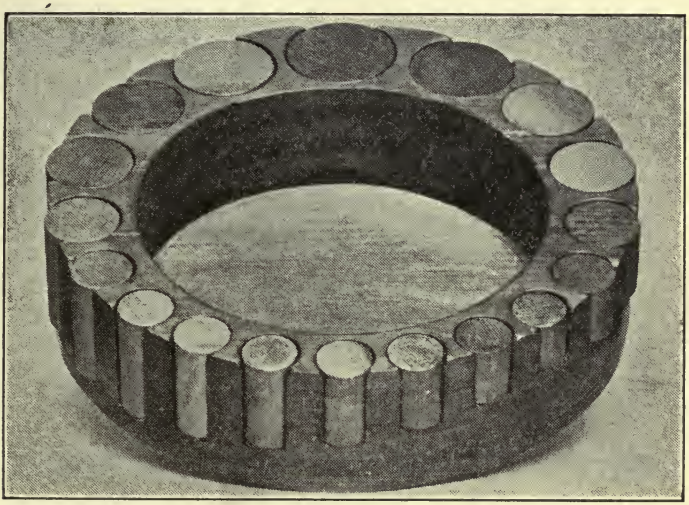
Fourth: A uniform method of procedure could be adopted for all ages.

Fifth: No instructions would be necessary that would place any premium upon language.

So the Montessori cylindrical insets were adopted by Professor Witmer for use in the clinic and were presented in four series, the three separate pieces and the three used together. This last arrangement consisted of placing the three blocks in a triangular position on the table in front of the child, the third block (varying in height) parallel to the edge of the table and forming the base of the triangle, the second block (varying in height and diameter) forming the right side and the first block (varying section) forming the left side. The thirty cylinders were all removed and placed within the enclosed triangle, mixed together, and the child was instructed to put them back in their proper places. Here was a performance test of considerable difficulty, which was of use with all ages beyond those with which the single sets were useable and which promised to permit of a quantitative standardization.

But there were certain inherent difficulties which made a satisfactory standardization doubtful. In the first place, the knobs on the cylinders, which were of value in the "psycho-sensory training," caused many false moves and errors. The block could be handled with more speed if grasped than when picked up by the knob and this meant many errors through dropping the cylinder into its correct hole knob downwards, then removing it under the belief that there had been an error of position. The loss of time resulting from this was often out of proportion to the

nature of the error. Then too, there were duplications of blocks, the first blocks of the last two sets being identical, the seventh blocks of the first two sets and the seventh block of the third set being identical with the first block of the first set. While this was not a serious drawback, it was more desirable that each cylinder have but one proper recess. Another objection was that for younger children especially, the cylinders represented three psychologically different classes of objects, the greater part being cylinders, but some being disks and others sticks.

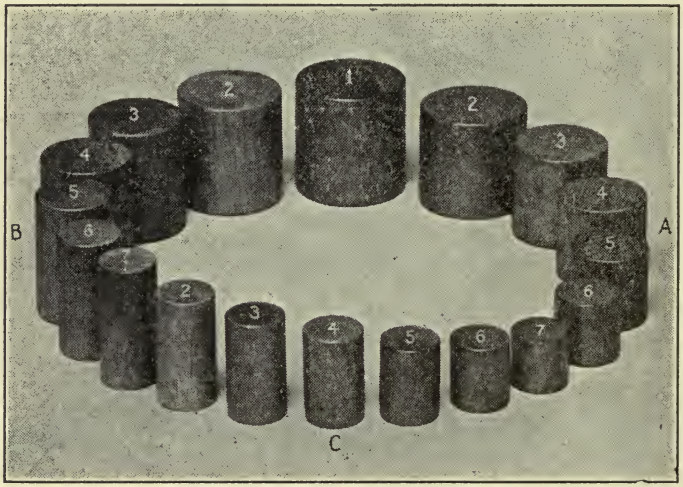


The Witmer Cylinder Test

In the Spring of 1915, Professor Witmer began to construct a piece of apparatus based upon this material, but which would possess the advantages without the disadvantages above enumerated. The Witmer Cylinder Test was the result. One board instead of three, made of a light wood, contains eighteen blocks instead of thirty, the three smallest cylinders of each set being omitted as well as all duplications. There are no knobs, the ends being thus interchangeable.

The cylinder board is a circular board of 11¼ in. diameter and 2½ in. height. The recesses are drilled about the outer edge so as to form a slot which will give a side view of each recess as well as facilitate the removal of the cylinder. This slot is made as

small as is consistent with the strength of the material, for it is desired that the perception of the recess be influenced as little as possible. In the center is a circular compartment of 8 in. diameter and 2 in. depth. The cylinders will be spoken of in this work as though divided into three series corresponding to the original sets of Montessori. The series varying both in diameter and in height (which will be called Series A) begins at the top of the board with a cylinder $2^1/_8$ in. in each dimension. Then along the right side of the board the successive cylinders are $1^{15}/_{16}$ in.,



Arrangement and Designations of Cylinders

$1\frac{3}{4}$ in., $1^9/_{16}$ in., $1^3/_8$ in., $1^3/_{16}$ in. and 1 in. in both dimensions. For convenience in identifying them, these cylinders will be spoken of as numbers 1, 2, 3, 4, 5, 6 and 7 respectively of Series A. The series of constant height and varying diameter begins at the top of the board and comes down the left side (called here Series B), the height being constant at $2^1/_8$ in. while the diameters decrease successively as in Series A. The one cylinder $2^1/_8$ in. in each dimension serves as No. 1 of both Series A and Series B, then the corresponding numbers of these two series have the same diameter but differ in height. The last block of Series B (B7) is one of the blocks corresponding to an original duplication and hence is also considered as No. 1 of Series C, which forms the remainder of

the circle. Series C has a constant diameter of one inch, but the height decreases as in Series A, hence corresponding numbers of these two series have equal heights but differ in diameter, including A7, which is logically a member of each series.

The three blocks which represent the original duplications are given two designations because of the fact that in practical work, a series is thought of as composed of seven cylinders, but the extremities are at the same time considered as members of other series. The use of some system of designation will be seen to be necessary since the similar character of the pieces prevents the use of distinctive names.

II

THE STANDARDIZATION

As soon as the final form of this board had been determined upon and the preliminary experiments upon method of procedure had been made, this quantitative standardization was begun. The method adopted was that used by Young (19) in his work on the formboard, an age distribution of a large number of unselected cases proportioned among different social classes.

The test was given in four of the public schools of Philadelphia, one of which is located in a slum region where the population is largely foreign born or native born Jewish. Another is in a suburban manufacturing district, where a considerable proportion are foreign born. In this part of the city, the living conditions are much better than in the first section, almost all the population living in small detached frame houses. The third is in a somewhat isolated suburb, where the population is composed mainly of the native born working class, with a large percentage of the business class. The living conditions are quite good. The fourth school is located in a part of the city occupied by the professional and business class. In order to fill out certain of the age groups, a number were examined in a fifth school, close to the first mentioned, since the proportion of cases from that social level was somewhat less than had been obtained from the others. While an approximately equal number of cases were examined from each of the four types of schools, they are not evenly distributed among the age groups. There is, however, an approximately equal distribution among the two social classes, the poorer, represented by the first two schools, and the middle class, represented by the last two schools. These correspond to the two groups used by Young in his standardization.

In the work with these children, there was no selection of cases whatever. When the examination of the children of any room was begun, they were taken one at a time according to seating

order, no distinction being made in the treatment of results between foreign and native born, or between the feeble-minded and the supernormal. Numerous cases were examined that were quite evidently of defective mentality, but the discarding of any of these cases would have required the same treatment of the especially bright children, which would not have given a sampling of the entire population of that age. Physical disability was the only ground for discarding results, an arm paralyzed or lost, sickness at the time of the examination, and one instance of peculiar performance quite evidently due to badly fitted glasses. No colored children are included.

The standardization of adult men has been taken from the two mental extremes, one group composed of college students and of students at one of the army aviation schools, the other group being inmates of the Indiana Reformatory. A number of prisoners was included equal to the number of cases in the first group, following the method of Simpson (9) who holds that the median performance of two such widely varying groups should give an indication of what would be the average of the entire population. For adult women, we have available only the results of college women. The reliability of this norm will be discussed in its proper place.

There were 2230 cases used in this standardization, 1722 school children, of whom 867 were boys and 855 girls, and 508 adults, 354 men and 154 women. For each age from eight to thirteen inclusive, a hundred boys and a hundred girls were used. For the ages six, seven, fourteen and fifteen the attempt was made to approximate this number, but due to certain defects in the results for these years, which will be brought out at a later point in the discussion, this number was not considered necessary.

All the grade school cases were tested by the writer, as were the men in the aviation school, but the college men and women, all of whom were graduate or undergraduate students in the course in General Psychology at the University of Pennsylvania, were tested by members of an advanced psychology course, under the direction of the writer. The Indiana Reformatory cases used in the standardization proper, were tested by Mr. C. P. Stone,* pys-

*The writer wishes to express his appreciation of the cooperation of Mr. Stone in the gathering of this material.

chologist of that institution, while a large part of the cases from that institution used in a later table were examined by the writer.

Procedure

In view of the emphasis that all authors have laid upon identity of procedure, it should be unnecessary to say that in order that the results of other examiners may be interpreted on a basis of this investigation, the same rules of procedure must be adhered to. For this reason, it is desirable that the procedure be as simple as possible. Owing to the variety of possible errors, however, and the fact that, contrary to the opinion of Dr. Montessori, the apparatus is not "self-correcting," the instructions have been made quite exact and a careful consideration of the various possibilities is necessary in order that an examiner may be ready to cope with all the situations that may arise.

In testing a subject, a room should be used in which he may be alone with the examiner and may be free from all outside interference. Ask the subject to stand before a table in a well lighted spot, the height of the table used being proportionate to the height of the subject. It must not be so low as to require him to stoop, nor so high as to interfere with arm movements. A table of the usual height gives an adult of five feet nine inches perfect freedom of movement, yet it seems to bring the board too far below him to permit it to be seen to the best advantage. For this reason, the distance of the board from the near edge of the table cannot be definitely set, but it may be said roughly that when the subject is standing erect at the edge of the table, the line of sight to the center of the board should make an angle of about sixty degrees with the plane of the table.

The board is placed with the series of one inch cylinders, Series C, adjacent to the subject, with the largest one, A1, directly opposite him. The solution of Series C is facilitated by having it where it may be seen, while it is of less advantage to see the larger recesses. The board must be kept turned in this way at all times, as it gives the subject a point of orientation.

First Trial. Before giving the instructions, it is necessary that the attention of the subject be upon the board, but placing him at the table in this position and moving the board before him has always been sufficient so that no further remarks were necessary before beginning the formal instructions. The aim in this

first trial is to require the subject to perform a new task with the least possible instruction. Therefore, the trial is carried where necessary, beyond the original instruction through a series of steps of training until he has completed the task satisfactorily.

Having drawn his attention to the board, say, "I am going to take these blocks out and place them in the center and I want you to put them back as quickly as you can." As the directions are being completed, begin to remove the cylinders with both hands, tossing them at random into the cenral compartment, the small ones first, then working up the opposite sides of the board at the same time so that the large cylinders will lie on top of the pile. If the small ones are permitted to remain on the top, there results a loss of time either in digging out the large ones, or in digging out the remaining small ones before going on to the larger, which introduces a variant that is better eliminated. Having done this, add, "You may use both hands. Begin when you are ready and do it as quickly as you can."

Take the time to the nearest second, preferably with a stopwatch, from the moment the first block is touched until the last block is placed in the correct recess.

Questions may be asked, especially by older subjects, but we have avoided answering all these, giving evasive replies, except in a few cases with aviators, who have asked whether the blocks taper, when the response was made that they were cylinders. Urging is in order should the subject begin to lag or lose interest, but no evidence should be given as to the correctness of placements. The questioning look of a child as he is in doubt may be best answered with the suggestion, "Hurry on!"

Should the subject quit with an error remaining on the board, whether from oversight or due to his conclusion that placing them by diameter, regardless of height, is sufficient, or should he give up the attempt with some unplaced, record the time at which he stops. This completes the first step; we are then ready to begin the steps of education, the instructions for which are:

Second Step: "Is that alright?"

Third Step: "That is not right."

Fourth Step: "Fix it so that they will be level with the top."

Each step ends when the subject ceases work either believing himself through, or being unable to complete the task. The watch should not be stopped before the end of the trial, but the

time of the completion of each step should be recorded, not that it is of use as a quantitative measure, but for its descriptive value.

This question in the second step should be asked in an off-hand manner, as though merely to remark, "Are you through already?" With adults, this bare question is sufficient in most cases to cause them to turn their attention again to the board and to begin to make corrections or ask about the correctness of their performance. Questions resulting directly from this instruction, as "Should they be level with the top?" may be answered where a simple affirmative or negative will suffice. With many older children, especially those who have merely stopped to see whether or not they are correct, or as we say, "quit for a decision," this instruction will be all that will be necessary. But with most young children, this question brings out either an affirmative answer or none whatever. A more definite instruction as in the third step must then be given them.

With normal individuals above the age of eleven, this third step is the last that is necessary. With young children or with cases of mental deficiency this may not be sufficient to suggest to them the right solution. Except in a few cases in the sixth or seventh years, normal grade school children require no more than the fourth step of instruction. When told that the cylinders must be level with the top, a child of school age will usually make the necessary corrections.

If this is not enough, point to some that are correct, rubbing the hand over them to indicate that they are level with the top. The next step would be to point to one that is wrong and require him to hunt for its correct recess until it is found. The purpose here is to give by small steps, the teaching that will enable the child to place the cylinders with his own hands. Whenever the subject has completed the task successfully, we are ready for the second trial.

In this standardization, it was considered necessary to set a five minute limit, when if the trial was not completed, even though but one or two steps of instruction had been given, the child was credited with a failure and was dismissed. Young set a three minute limit on the formboard. A time limit is needed in undertaking such an investigation as this, and it has been found that with grade children, none but those of low mental level require

more time than this other than in the ages of six, seven and eight. The question of failures will be taken up again in connection with the data.

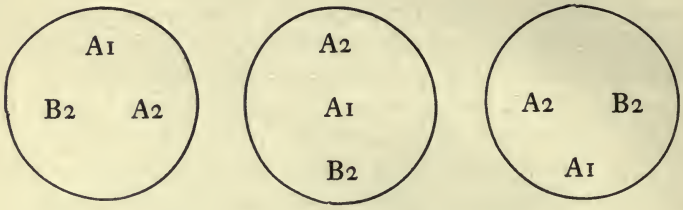
Second Trial. After declaring the work to have been satisfactory and giving some encouragement, as is advisable in all testing of children, remove the blocks in the same manner as before, saying as it is being done, "Now I am going to take them out again and I want to see if you can put them back even more quickly." Should the subject have used but one hand during the greater part of the time, it is well to add, "Use both hands this time." If he cannot work with both, this will not confuse him as he will soon cease to work with one of them. Take the time as in the first trial.

The second and third trials are not qualitative trials and no attempt at education is made, except in one instance. Should an error remain which is evidently an oversight rather than a failure to understand when the test is satisfactorily performed, require the subject to correct it but count that trial a failure. The reversal of an adjacent pair of blocks in Series C, or of A2 and B2 may be considered an oversight, or even an error further removed in the case of a younger child. Correction is never permitted except where the error has been quite evidently but an oversight, and it is allowed only as a caution for the next trial Should a more serious error be made, the entire test is considered a failure.

Third Trial. The instructions this time are, "Now once more. Let's see if you can do it even faster this time." The time is taken as in the preceding trials. No corrections need be permitted as this is the last trial. Final errors on the three trials would class the test as a failure, but no instances of this have been seen in cases who have completed the first trial within the five minute limit even with instruction.

It was discovered early that the time of the performance was affected more by the chance position of cylinders A2 and B2 than by any other variable. If A2 happened to be thrown on the right side of the compartment, it would probably be picked up with the right hand and hence would be placed in its own recess, while if it were thrown on the left hand side, it would be picked up in most cases with the left hand and then would ensue a period devoted to straightening out the difficulty. For that reason, a

definite order of placement of the three largest blacks was determined upon.



Trial I Trial II Trial III

POSITION OF LARGE CYLINDERS IN COMPARTMENT

In each trial, the largest cylinder, A1, is placed in the median line, at the top in the first trial, in the center in the second trial and at the base in the last trial. Blocks A2 and B2 are removed at the same time and in the first trial are thrown on the side adjacent to their recesses. The second time, these blocks are placed in the median line, which gives the child an equal chance of picking up a cylinder with the correct hand. On the last trial, A1 is placed at the near side of the compartment, to vary its position, while A2 and B2 are thrown to the opposite sides, thus requiring the child to accept the more difficult situation. Perhaps for practical purposes, it would be better to place these three in different positions on the median line in each trial. At least, it is necessary to eliminate variables so far as is possible and experience has shown that the chance placements of these cylinders by the examiner is the most important one.

When this test was first used, the procedure adopted included instructing the subject to put the cylinders "back where they belong" and in case errors were left, immediately telling him that they must be level with the top. But this procedure had two weak points; first, a time record made on the first trial with this additional information is not comparable to one made without this assistance; second, the equivalent instruction cannot be given to one who lacks the use of language, whether from deafness or from insufficient knowledge of our tongue. In order to avoid these difficulties and at the same time to make the test more of a problem, the instructions were changed to those now in use,

the subject being merely told to "put them back." The procedure as then used provided that in case final errors were left, the examiner was to make the corrections himself, without calling attention to them, the assumption being that this should be sufficient to suggest to the subject that his performance had not been satisfactory and to indicate the nature of the correct solution. But when given to a university class of a hundred and three students in this manner, there were three individuals who made observational errors (failed to observe that two cylinders were reversed) and each of these profited by the instruction; there were seventeen students, one-sixth of the class, who replaced the cylinders by diameter only, regardless of height, and of these, but five profited by this silent correction made by the examiner. Of the remaining twelve, four did the test correctly on the last trial but the other eight assumed that as nothing had been said, their performance has been satisfactory and they completed it in the same manner in each of the three trials. When less than a third of a university group draw the desired conclusion from the movements of the examiner, it is hardly to be expected that grade school children should profit by the corrections made before them and to which attention is not called. In order that a quantitative comparison may be made between the results of different subjects, it is necessary that at the end of the first trial all should have learned the nature of the problem.

Some experimenters may find that the method of least possible steps of instruction on the first trial makes too much of a demand upon their time when examining a group. Perhaps the chief consideration that has induced us to adopt a form of first trial requring the test to be satisfactorily finished by the child himself, is that we believe our records may be made use of without loss of reliability by anyone who will adopt this principle. It is but necessary that the child shall start the second trial knowing definitely from previous performance, just what he is to do. A deaf child, or one unable to use the English language, may complete the first trial, instructed only by signs, and is then ready to begin the quantitative trials on a level with the subjects that we have used in this investigation.

Methods of Scoring

There are five possible methods of scoring,—the time on the first, the second or the third trials, the average time, or the time

of the shortest trial. As to the first trial, enough has been said to show that it will not permit of quantitative standardization.

At the beginning of this investigation, it was thought that the second trial should be used, on the theory that after the individual had learned what was required of him, a single trial would give a valid time index. However, the precedent of three trials used in so many tests was followed pending an investigation into the validity of the various scoring devices. It was soon found that too often some single trial would show a slow time due to chance errors followed by mental confusion, or due to varying the method or order of placement, which would completely destroy the value of that trial. This was particularly true of bright children who, after making a fast record on one trial, would give a poor performance on the next due to excessive haste. Our records, even with college students and aviators, show that some one trial, usually the second, has a slow time because of too much haste or misfortune in making placements. What has been said of the second trial applies equally to the third trial, the children in the higher grades more often than adults using excessive haste on this trial.

The average of three trials cannot be used because of the impossibility of treating the first trial quantitatively. Certainly the time of completion of a trial in which there were three steps of instruction should not be brought into comparison with the time made with but the original instruction. Hence an average must be an average of two trials, the second and the third. This likewise is affected by any chance slow trials, though the excess is halved, but that there should be some penalty is not unreasonable. It may be that the best method of scoring this test would be found to be the giving of four trials and using the average of the last three. However, the time required and the fatigue induced are important elements in a clinical examination and would seem to suggest that even three trials is a little long in working with younger children.

In the shortest trial, chance plays less part. It is true that in certain instances a series of chance placements have given a final result much shorter in time than the other performances seemed to warrant, but there were fewer cases misplaced by this method than by any of the others. There are so many possibilities of error to be avoided in the cylinder test that luck will assist an individual much less than it will retard him. With the exception

of the few cases mentioned, the shortest trial has seemed to give us a more satisfactory determination when applied to individual cases than did any other scoring method. It is a better indication of what the child can do.

Sylvester (12) tested experimentally the various scoring devices as applied to the formboard and came to these conclusions; First Trial, the performance is too irregular to be of value; Third Trial, "Bright children often fall back through over-hurrying, change of method of handling the blocks or bad luck in fitting them into the recesses;" Shortest Trial, This is the most regular and has the lowest variability, hence statistically is the most reliable; Average of Three Trials, seems the most satisfactory with individual cases, probably due to the fact that it gives weight to the first trial.

Our own investigation gave less concrete results than that of Sylvester. In the first school that was tested, each of the teachers from the first to the sixth grade inclusive was asked to place the members of each of her classes in a rank order, boys and girls separate. The instructions were given them in such a way as to endeavor to get a ranking on a basis of intelligence or general ability rather than upon school performance. There was a great variation in the resulting material, the personal element being very large, so that the results do not warrant presentation. However, an investigation into the lists which showed marked correspondence or marked difference between the teacher's rank order and the rank order of cylinder test performance was the basis of the conclusions that have been drawn above. It leads us to agree with Sylvester, except that the shortest trial instead of the average of three trials proves the most satisfactory in individual cases.

In connection with the investigation of the relation between cylinder test performance and shop ability, presented in Chapter V, the question of the value of the various methods of scoring is again taken up and from another angle. It will suffice here to point out that Table 8, page 50, indicates that the shortest trial is the most satisfactory index, followed closely by the average of two trials, while the first trial and the average of three trials are much less suitable.

Method of Recording

The method of recording any test must not be so complicated as to detract the attention of the examiner during the progress of

the test, yet it must adequately portray the important points. The examiner employing this test for the first time may find it difficult to report his results, particularly of the first trial with its complex possibilities, without missing much of the subject's performance. For this reason, sample records will be given to illustrate the system used in this investigation and to demonstrate some of the short cuts of reporting that have been worked out.

Case 251 Name, A. D. Age, Adult Sex, M
(1) 48-6 Diameter; approximate positions.
62 "Are they supposed to be level?"
(2) 42
(3) 36*

In this case, the blocks were returned in 48 seconds with six errors remaining, the subject placing them by diameter only, except that they were close to the correct position. In response to the question, "Is that right?" he responded, "Are they supposed to be level?" An affirmative answer was given as this question had been enough to suggest to him the correct solution. He is therefore credited with two steps on the first trial, requiring a total time of 62 seconds. The second and third trials were preformed in 42 and 36 seconds respectively, a star being placed after the time of the third trial to indicate that it is the shortest trial.

Case 2047 Name L. R. Age, 8 yr. 4 mo. Sex F
(1) 125–10 By diameter only; A1 in compartment.
Yes
183-8 Meaning not understood.
205–2 C 6, 7.
214

(2) 109*

(3) 74–2 AB 2.

In this instance, the child returned the blocks to some recess without regard to height, but stopped work as though through with the largest block still lying in the central compartment. At this time, 125 seconds, there were ten errors remaining. In response to the question of the second step, she answered, "Yes," so the third step was given her, the statement, "That is not right." This time she placed every cylinder in some recess, finally stop-

ping with eight incorrect placements. It was evident that she did not yet understand what should be done. She was told to fix them so that they would be level with the top and then began to understand what was wanted, with the result that at the end of 205 seconds, all had been correctly returned with the exception of the reversal of C6 and C7, an observational error. A fifth step was necessary, in this case it being enough to tell her that she was not yet through. She then found her error and corrected it, the total time consumed in the entire trial being 214 seconds. As several seconds are required to be sure that the child has stopped work and to give the additional instructions, it is evident that the last correction was quickly made. Her second trial required 109 seconds and the third 75 seconds, but this time she left two final errors, A2 and B2 being reversed. This trial being thrown out because of final errors, the time used as the index is that of the second trial, 109 seconds.

This simple combination of the numbers of two blocks had been found very convenient to represent a reversal, thus AB3 indicates that the third blocks of series A and B have been reversed, or C 4,5 indicates a reversal of the fourth and fifth cylinders in Series C.

III

TREATMENT OF RESULTS

For this standardization, an effort was made to obtain fifty cases of each sex for each half year group. But it was found that for the sixth and seventh years, the test is too difficult to be performed within the five minute limit allowed for the first trial. Less than a half of the boys and even a smaller proportion of the girls completed the trial within this period and it was therefore considered that the determination of the performances for these ages is a separate task, for the proper solution of which, any amount of time necessary must be given in order that the first trial may be completed. The greater part of the successful trials given in the tables for the seventh year were from children who were in the latter half of that year. The material for these ages is included in the data simply to give an indication of what some children of that age can do and in order that it might be utilized, should it fit in with any further investigation of these ages.

Beginning with the eighth year, the percentage of those who fail to complete the test within the time limit is not large. Those who have been placed in our poorest group through failure to complete the first trial would fall quite generally in the poor group even if sufficient time were allowed for them to complete it, as will be shown later. So then, for the ages from eight to thirteen inclusive, the results are complete for fifty boys and fifty girls of each half year group, one hundred for each year. The results for the fourteenth year are satisfactory, although the range of ability represented is probably not what might be desired. In the first place, the greater part of the cases come within the first half of this year, fifty of each sex as compared with thirty-two girls and forty-four boys in the last half of the year. Then the children of this age are in the seventh or eighth grades, mainly the latter. While in the preceding ages we have had the brightest as well as the poorest, the pedagogically advanced as well as the pedagogic-

ally retarded, in this age we have the pedagogically "at age" and the retarded, but the brightest and the pedagogically advanced are out of the grades. This is particularly true of the girls.

That this is not a serious drawback is indicated by the fact that the resulting curve corresponds with what other investigators have found. There is a steady decrease in time for both sexes up to the age of fourteen, when there is a slight increase for boys, while for girls it remains the same except for an increase in the minimum. The same tendency at the fourteenth year was found by Pintner and Patterson (8) in most of their performance tests and by Sylvester (12) and Young (19) on the formboard. None of tbese has explained this rise on the basis of insufficient distribution of the mental grade of this year, which is probably the cause. The fact that this is a performance test rather than an intelligence test suggests that this lack of distribution is not as serious as it would prove for tests more dependent upon language ability. As the half-yearly increments of mental growth are not as large as in earlier ages, a fewer number of cases can be of as much value in constructing the curve of normal distribution, nor would the slight excess of cases in the first half of the year greatly affect the final curve.

The fifteen year group is not satisfactory for either sex as all the cases are over-age for their grade and cannot be considered as typical of the age. Neither sex surpasses the thirteen year group in performance, and the girls of this age do poorer work. The high percentage of cases requiring over fifty seconds on the shortest trial, as shown in Table 2, is due to two things, the nervousness of girls of this age when facing a test, resulting in qualitative performances that would be poor for girls several years younger, and the fact that girls of this age quite generally perform the test because they have been asked to, seem satisfied if they do it at all, and seldom show competetive spirit.

There is a considerable age range in the adult group. Among the university students are included a number of men and women who are graduates students or who are registered in the College Course for Teachers and are older than the usual college students. The aviator group runs from twenty-three to twenty-eight years of age, most of them being college graduates. The Indiana Reformatory receives men between the ages of sixteen and thirty at the time of commitment, the mean age being twenty-two. The

records of this group were obtained at the time of the mental examination about a month after admittance. One hundred seventy-seven consecutive cases have been used in which the cylinder test was given, the only source of error being that the test was not given to everyone, being in some cases omitted for lack of time, where the things that this test brings out had been determined in other ways. This tends to eliminate the men of better mentality and to give us figures from a more uniformly poor group.

Unfortunately our distribution for women contains only the picked group, university students, and because of this it cannot be said to be representative of the range of adult women.

TABLE I

DISTRIBUTION OF SHORTEST TIME TRIALS—1221 BOYS

F.	1	1									
D N. C.	29	20	8	13	4	6	1	1			
195	..	1	...	...	...	...	...	...	..	..	...
186	..	1	...	...	...	...	...	...	..	..	...
167	1	..	...	...	...	...	...	...	..	..	...
152	..	..	1	...	...	...	...	...	..	..	...
144	..	..	1	...	...	...	...	...	..	..	...
140	1	..	...	...	...	...	...	...	..	..	...
139	..	..	1	...	...	...	...	...	..	..	...
137	..	1	...	...	...	...	...	...	..	..	...
132	..	..	1	...	...	...	...	...	..	..	...
124	..	1	...	...	...	...	...	...	..	..	...
121	..	..	1	...	...	...	...	...	..	..	...
117	..	1	...	...	...	...	...	...	..	..	...
114	..	1	...	...	...	...	...	...	..	..	...
112	1	..	...	...	...	...	...	...	..	..	...
111	..	..	1	...	...	...	...	...	..	..	...
108	..	..	...	...	...	1	...	...	..	..	...
107	..	..	1	...	...	...	...	...	..	..	...
106	..	..	1	...	...	...	...	...	..	..	...
105	..	..	...	...	...	...	1	...	..	..	...
104	..	..	...	...	...	...	...	...	..	..	...
103	2	..	...	...	...	...	...	...	..	..	...
102	..	..	...	...	...	...	...	...	..	..	...
101	..	..	1	...	...	...	...	...	..	..	...
100	1	..	...	...	...	...	...	...	..	..	...
99	..	..	1	...	...	...	...	...	..	..	...
98	1	..	...	...	...	...	...	...	..	..	...
97	..	..	...	...	...	...	...	...	..	..	...
96	1	..	...	...	...	...	...	...	..	..	...
95	2	1	...	...	...	...	...	...	..	..	...
94	..	..	1	...	...	...	...	...	..	..	...
93	..	..	...	...	...	1	...	...	..	..	...
92	..	..	...	...	...	...	...	...	..	..	...
91	..	..	1	...	...	...	...	...	..	..	...
Age	6	7	8	9	10	11	12	13	14	15	Adult

TABLE I—CONTINUED

90	1	..	...	1	...	...	...	...	..	..	...
89	..	1	...	...	...	...	...	...	..	..	...
88	..	..	...	...	...	...	...	...	..	..	...
87	..	1	...	...	...	...	...	...	..	..	...
86	..	..	1	...	...	...	...	...	..	..	...
85	1	..	...	...	...	...	...	...	..	..	...
84	..	1	...	...	...	...	...	...	..	..	...
83	..	..	1	...	...	...	...	...	..	..	...
82	..	1	1	...	...	...	...	...	..	..	...
81	..	..	1	...	...	...	...	...	..	..	...
80	..	1	...	...	...	...	1	...	..	..	...
79	1	..	1	1	...	...	...	...	..	..	...
78	..	3	...	...	1	...	...	...	..	..	...
77	..	1	1	...	...	...	...	...	..	..	...
76	1	1	1	...	1	...	...	...	..	..	...
75	..	..	...	1	...	...	...	...	..	..	...
74	..	3	...	1	...	...	...	...	..	..	...
73	1	1	2	3	...	...	...	...	..	..	...
72	..	1	3	...	2	...	...	...	..	..	...
71	..	2	3	2	...	...	...	...	..	..	...
70	1	..	3	...	1	...	...	...	..	..	...
69	1	..	2	...	...	...	...	...	..	..	1
68	..	..	...	1	...	...	...	...	..	..	...
67	2	2	3	3	1	1	...	1	..	..	...
66	..	1	2	1	2	...	1	...	..	..	...
65	..	3	3	2	...	...	1	...	..	..	...
64	..	1	2	1	...	1	...	1	..	..	...
63	..	1	1	2	...	1	1	...	..	..	...
62	2	2	4	1	1	...	1	...	..	..	...
61	2	2	3	2	2	2	1	...	1	..	...
60	1	1	1	1	3	...	...	...	..	..	1
59	..	1	2	1	2	...	...	1	..	..	2
58	1	2	2	3	2	4	1	...	1	..	...
57	1	1	1	1	1	2	2	1	..	..	1
56	1	1	3	3	3	1	...	...	..	..	...
55	..	3	3	2	1	1	1	1	..	..	...
54	..	..	...	1	6	...	1	...	1	..	1
53	..	2	4	5	6	1	3	...	1	2	2
52	..	1	4	1	5	...	4	1	..	1	2
51	..	..	2	3	3	3	2	2	1	..	...
50	..	1	2	3	4	2	...	3	3	1	...
49	..	..	3	4	6	4	2	3	1	1	...
48	..	1	1	5	5	3	2	...	1	..	5
47	..	..	1	3	3	6	2	1	4	1	1
46	1	..	2	3	1	4	2	5	5	..	6
45	..	1	1	2	1	3	2	1	6	..	8
44	..	..	1	4	4	3	7	2	6	3	9
43	..	2	2	4	6	7	5	4	4	1	5
42	..	..	2	...	3	7	7	4	4	2	5
41	..	1	...	4	1	5	6	5	2	2	12
Age	6	7	8	9	10	11	12	13	14	15	Adult

TABLE I—CONTINUED

40	..	..	2	1	1	4	5	9	8	2	17
39	..	..	1	2	2	3	3	...	7	2	13
38	..	..	...	2	2	3	6	5	4	1	11
37	..	..	1	2	5	4	5	6	2	5	17
36	..	..	...	...	3	3	2	2	3	2	18
35	..	..	...	2	...	6	3	3	3	3	18
34	..	..	...	1	2	...	3	7	7	1	21
33	..	..	1	...	1	3	2	5	3	3	14
32	..	..	...	...	3	2	4	8	3	5	26
31	..	..	...	1	...	...	1	2	2	..	22
30	..	..	...	...	...	1	3	5	1	1	21
29	..	..	...	...	...	...	2	2	2	1	24
28	..	..	...	...	...	...	1	5	2	..	11
27	..	..	...	...	...	...	...	1	2	..	13
26	..	..	...	1	...	1	3	1	2	..	9
25	..	..	...	...	...	1	...	1	..	..	16
24	..	..	...	...	...	...	...	...	1	..	4
23	..	..	...	...	...	...	...	1	1	..	7
22	..	..	...	...	...	...	...	...	..	..	4
21	..	..	...	...	...	...	...	...	..	..	4
20	..	..	...	...	...	...	...	...	..	..	2
19	..	..	...	...	...	...	...	...	..	..	...
18	..	..	...	...	...	...	...	...	..	..	1
No.	58	75	100	100	100	100	100	100	94	40	354
Age	6	7	8	9	10	11	12	13	14	15	Adult

TABLE II

DISTRIBUTION OF SHORTEST TIME TRIALS—1009 GIRLS

F. D. N. C.	27	31	18	1 10	8	3	1		1	2	
205	..	1	...	...	...	...	...	...	..	..	...
188	..	1	...	...	...	...	...	...	..	..	...
177	..	1	...	...	...	...	...	...	..	..	...
136	..	1	...	...	...	...	...	...	..	..	...
107	..	1	...	...	...	...	...	...	..	..	...
106	..	..	...	...	...	...	...	...	..	..	...
105	..	1	2	...	...	...	...	...	..	..	...
104	..	..	...	...	...	...	...	...	..	..	...
03	.	..	...	...	...	...	...	...	..	..	...
102	..	..	...	...	...	...	...	...	..	..	...
101	2	..	...	...	...	...	...	...	..	..	...
Age	6	7	8	9	10	11	12	13	14	15	Adult

TABLE II—CONTINUED

100	..	..	...	...	...	...	...	...	..	..	...
99	..	..	...	1	...	...	1	...	..	..	...
98	..	..	1	1	...	1	...	...	1	..	...
97	..	..	...	...	...	...	...	...	..	..	...
96	..	..	...	...	...	...	1	...	..	..	...
95	..	..	1	...	...	...	...	...	..	..	...
94	..	..	...	...	1	...	...	1	..	..	...
93	1	..	1	1	...	...	...	...	..	1	...
92	..	1	1	...	...	...	...	...	..	..	...
91	..	1	3	...	...	...	...	1	..	..	...
90	..	2	...	...	...	...	...	...	..	..	...
89	..	1	1	...	...	...	...	...	..	..	...
88	1	2	...	...	...	...	...	...	..	..	...
87	..	1	...	...	...	...	...	...	..	..	...
86	..	..	...	...	1	...	...	...	..	..	...
85	..	..	2	1	1	...	1	...	..	..	...
84	..	..	1	1	...	...	...	...	..	..	...
83	1	1	1	...	...	...	...	...	..	..	...
82	..	2	1	...	...	...	...	...	..	..	...
81	..	1	1	1	...	...	...	...	..	..	...
80	1	1	...	...	1	...	...	...	..	..	...
79	..	1	1	...	...	...	1	...	..	..	...
78	1	3	1	1	...	...	...	...	..	1	...
77	1	..	1	...	...	1	...	...	..	1	...
76	..	1	1	...	...	...	1	...	..	..	...
75	..	3	3	2	1	1	1	...	..	1	...
74	..	..	1	3	...	...	...	1	..	1	...
73	1	1	...	1	...	...	1	...	..	..	...
72	..	3	...	1	2	...	...	...	1	..	...
71	..	2	2	2	...	...	1	1	..	..	...
70	..	..	2	2	...	1	...	...	..	..	...
69	1	..	3	1	...	...	1	1	..	..	...
68	1	..	2	2	5	...	...	...	..	..	...
67	..	1	2	4	1	...	...	...	..	..	...
66	2	1	...	1	4	2	...	...	..	1	1
65	..	2	1	4	1	2	...	4	1	..	...
64	..	1	1	1	1	...	1	...	..	..	...
63	..	2	1	1	...	1	1	2	1	..	...
62	..	1	5	3	1	...	1	...	..	..	1
61	..	..	4	1	...	1	1	1	..	..	1
60	..	2	...	...	1	4	...	...	..	..	3
59	..	2	4	5	2	2	1	3	1	1	...
58	1	..	4	1	3	2	1	...	..	..	...
57	..	2	2	2	3	6	1	1	1	..	...
56	1	..	4	1	4	2	...	1	..	2	...
55	1	..	3	3	2	5	1	1	2	..	1
54	..	..	1	4	1	2	3	...	2	..	...
53	..	1	2	2	1	2	2	4	1	1	2
52	..	..	1	5	2	2	3	...	4	..	1
51	..	1	4	2	3	6	2	2	2	..	2
Age	6	7	8	9	10	11	12	13	14	15	Adult

TABLE II—CONTINUED

50	..	1	...	5	2	6	3	3	2	2	...
49	..	1	...	1	1	1	2	5	3	1	3
48	..	..	1	2	5	2	4	3	3	2	4
47	..	..	1	3	4	6	7	2	7	..	1
46	..	..	3	6	5	4	3	4	1	3	1
45	..	..	...	1	8	3	3	2	1	1	3
44	..	1	...	4	1	4	4	3	2	2	4
43	..	..	1	...	3	1	5	3	3	..	1
42	..	..	2	1	3	...	7	6	4	3	7
41	..	..	2	1	2	6	1	2	6	2	5
40	..	..	...	1	4	4	5	8	4	1	4
39	..	..	...	...	2	3	5	6	3	1	2
38	..	..	...	1	3	1	2	4	2	3	6
37	..	..	...	...	1	...	3	4	5	3	...
36	..	..	...	1	2	4	...	9	5	1	5
35	..	..	...	1	1	2	2	...	3	1	5
34	..	..	...	...	2	2	5	1	1	2	8
33	..	..	...	1	...	3	1	...	3	..	9
32	..	..	...	...	1	1	4	3	1	1	14
31	..	..	...	...	...	...	3	2	1	..	12
30	..	..	...	...	...	1	...	1	2	2	7
29	..	..	...	...	...	...	3	1	1	1	7
28	..	..	...	...	...	...	...	2	..	2	7
27	..	..	...	...	...	...	...	1	1	..	8
26	..	..	...	...	...	...	...	...	..	1	6
25	..	..	...	...	...	...	...	1	..	..	4
24	..	..	...	...	...	...	...	...	..	..	2
23	..	..	...	...	...	...	...	...	..	..	2
22	..	..	...	...	...	...	...	...	..	..	...
21	..	..	...	...	...	...	...	...	..	..	2
20	..	..	...	...	...	...	...	...	..	..	1
19	..	..	...	...	...	...	...	...	..	..	...
18	..	..	...	...	...	...	...	...	..	..	2
No.	43	83	100	100	100	100	100	100	82	47	154
Age	6	7	8	9	10	11	12	13	14	15	Adult

The distribution of the shortest time trials from 1221 men and boys is given in Table 1 and from 1009 women and girls in Table 2. The total number of cases examined for each age is stated and the cases are then distributed by seconds. At the top of the column, under the heading D. N. C. (Did Not Complete) is given the number who were credited with failures through inability to complete the first trial within the five minute limit. Above that, under the heading F. (Failure) are placed those who after com-

pleting the first trial, failed to give a completed trial on either the second or the third trial. One boy comes within this group who finished the first trial with several steps of instruction but upon the second trial he had shown no evidence of ability to complete the task at the end of five minutes. There are also included a boy and a girl who had required several steps of instruction on the first trial and then on both the second and third trial left observational errors. Those who succeeded on the first trial with only the original instructions would be credited with this time as their shortest if final errors were left on both the second and the third trials, as happened in one instance.

TABLE III

QUINTILE DISTRIBUTION—BOYS

Age	No.	F.	Mean	S. D.	Min.	20%	40%	Med.	60%	80%	Max.
6	58	30	82.43	26.57	46	69	103	DNC	DNC	DNC	DNC
7	75	21	73.98	29.69	41	58	69	76.0	87	DNC	DNC
8	100	8	66.54	23.36	33	50	59	63.5	68	88	DNC
9	100	13	52.48	11.98	26	43	49	52.9	57	72	DNC
10	100	4	49.49	10.00	32	41	48	49.8	52	58	DNC
11	100	6	45.26	11.73	25	37	42	43.5	46	55	DNC
12	100	1	43.16	11.48	26	35	40	41.6	43	51	DNC
13	100	1	38.66	8.40	23	32	35	37.7	40	46	DNC
14	94	0	39.60	7.43	23	33	39	39.7	43	46	61
15	40	0	38.87	6.35	29	33	36	37.3	39	44	53
Ad.	354	0	34.20	7.34	18	28	32	33.5	35	40	69

TABLE IV

QUINTILE DISTRIBUTION—GIRLS

Age	No.	F.	Mean	S. D.	Min.	20%	40%	Med.	60%	80%	Max.
6	43	27	75.75	14.23	55	77	DNC	DNC	DNC	DNC	DNC
7	83	31	80.79	31.58	44	65	80	89.0	177	DNC	DNC
8	100	18	65.77	14.79	41	55	62	68.0	75	101	DNC
9	100	11	58.51	13.56	33	47	54	58.9	65	74	DNC
10	100	8	52.07	12.53	32	42	47	50.5	56	67	DNC
11	100	3	49.50	10.97	30	40	47	49.7	51	58	DNC
12	100	1	47.06	13.50	29	37	42	44.5	47	54	DNC
13	100	0	45.88	12.29	25	36	40	42.3	46	53	94
14	82	1	44.10	10.43	27	36	41	42.2	46	51	DNC
15	47	2	45.71	14.81	26	35	40	42.4	46	56	DNC
Ad.	154	0	35.41	9.29	18	28	32	33.2	35	42	66

This material is presented in Tables 3 and 4, distributed by quintiles and accompanied by means, standard deviations and

medians. These tables are identical in construction with those of Young (19) on the formboard and Humpstone (4) on the memory span. The first column lists the ages, the second the total number of cases examined, the third the number of failures, in this case the term including both those listed as D. N. C. and the failures in the previous tables. The mean has but little value in a work such as this as it places undue emphasis upon the extreme cases, particularly the slow ones. The median, on the other hand, gives equal weight to all the cases. The time values of the minimum, the maximum and the intervening quintiles are given, with the cases of failure to complete the first trial (the D. N. C. group) included in the distribution as the poorest group.

In an effort to determine whether we were warranted in placing these failures in the upper quintiles, six control cases were used. These were children whose qualitative performances were such as to suggest that they were among the best of those who failed to come within the time limit. We might expect that they would profit most by a removal of the limit. These six were permitted to complete the first trial and were then given the second and third trials. A quintile distribution was then made for each sex on a basis of the number completing the test, omitting all failures. Placing these control cases in this new distribution, four of the six children still fell in the fifth, or poorest, quintile, the other two being raised to the second quintile.

Of those children requiring from 260 to 300 seconds to complete the first trial, just within the limit, we find that for those below the age of nine, three are in the first quintile, six in the second, two in the third, two in the fourth and eleven in the fifth; of those nine years of age or more, there are two whose shortest trial places them in the first quintile, two in the second, three in the third, five in the fourth and six in the fifth. These two control groups give distributions which lead to the following conclusions:

(1) Had sufficient time been given to complete the first trial, our failures of the ages six, seven and eight would have been distributed throughout the scale but would tend to fall largely in the poorest half.

(2) This disposition does not do justice to the failures in the ages of six and seven, for which years the standardization can only be made by extending the time limit to such a point as will permit almost the entire number to complete the first trial.

(3) The distribution for the eighth year is not so seriously affected, owing to the much smaller proportion of the failures, for here we find that but few would fall in the higher quintiles.

(4) Above the age of eight the number of failures is quite small and the evidence shows that they would fall almost entirely in the last two quintiles.

(5) Such a completion of our material, then, might raise the median and the sixty percentile slightly, but the proportion of this change to the range of distribution would be small. The boundary between the fourth and fifth quintiles would suffer the greatest increase.

(6) The assignment of the failures to the upper end of the distribution is therefore justified. It gives a more reliable result than would be obtained from the only alternative, a distribution of successful cases, the failures being discarded.

A graphical representation of the material of Tables 1 and 2 is given in Graphs 1 and 2, distributed by quartiles. These curves show with increasing age a steady decrease in time of performance and a decrease in the range of the quartiles. The minimum line has this same tendency but is subject to the influence of individual exceptional cases. The line of the lower quartile shows a steady decrease and a smooth curve in each table. The displacement in the median line at ten years for boys and eleven years for girls is probably due to a greater proportion of children from the poorer social group. The quota of boys in the last half of the tenth year and of the girls in the first half of the eleventh year had not been filled when the examination of the other ages had been completed, so the remaining cases were taken from the school then being used, which was one of those described as being of the poorer class. The rise in the median and upper quartile of fourteen year old boys has been explained as has the rise in the upper quartile for fifteen year old girls. The maximum curve is not drawn because of the inclusion of the D. N. C. cases at this end.

The most comprehensive graphical representation of any distribution is given by the percentile curve. The grouping of the curves for the various ages as is done in Graphs 3 and 4, permits a comparison of the results of any individual with those of the other ages as well as with those of his own age. In formulating the curves given here, a variation from the accepted method was necessary

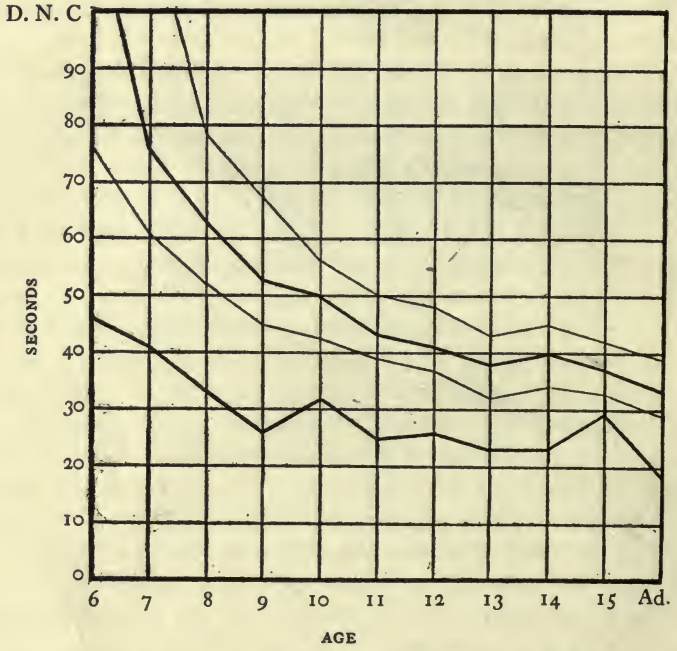
at the lower end. As the failures are placed here, each line is begun at that point at which the slowest case occurs. Thus, eight ten year old girls of the hundred failed to complete the test, the ninth had a record of 94 seconds. The curve for ten year old girls is therefore begun at 9 per cent, 94 seconds.

To find the percentile rating of an individual, follow the vertical

GRAPH I

QUARTILE DISTRIBUTION

BOYS



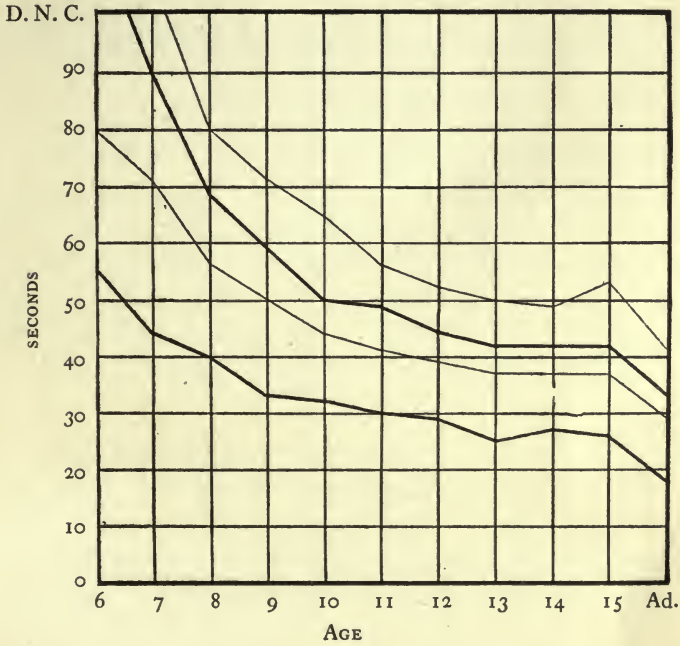
line corresponding to the number of seconds of his shortest trial to its intersection with the curve of his age. At this point the horizontal per cent line indicates where he falls in the distribution of individuals of that age. By way of illustration, to determine the rating of a twelve year old boy who has performed the test in 35 seconds, follow the 35 second line to the intersection with the twelve year old curve, which will be seen to be at 82 per cent, which means that this boy has done better than four-fifths of the boys of that age, or to be more exact, that 81 per cent have done more poorly than he and 18 per cent have performed more quickly.

The comparison of a boy with others of his age is more important than comparing him with the standards of other ages, but if it should be desired to do this, it is only necessary to run along the 35 second line, to use the same case again, and note the points at which the other curves cross. Thus, 35 seconds is the 89 per cent performance of eleven year old boys, the 67 per cent performance

GRAPH II

QUARTILE DISTRIBUTION

GIRLS



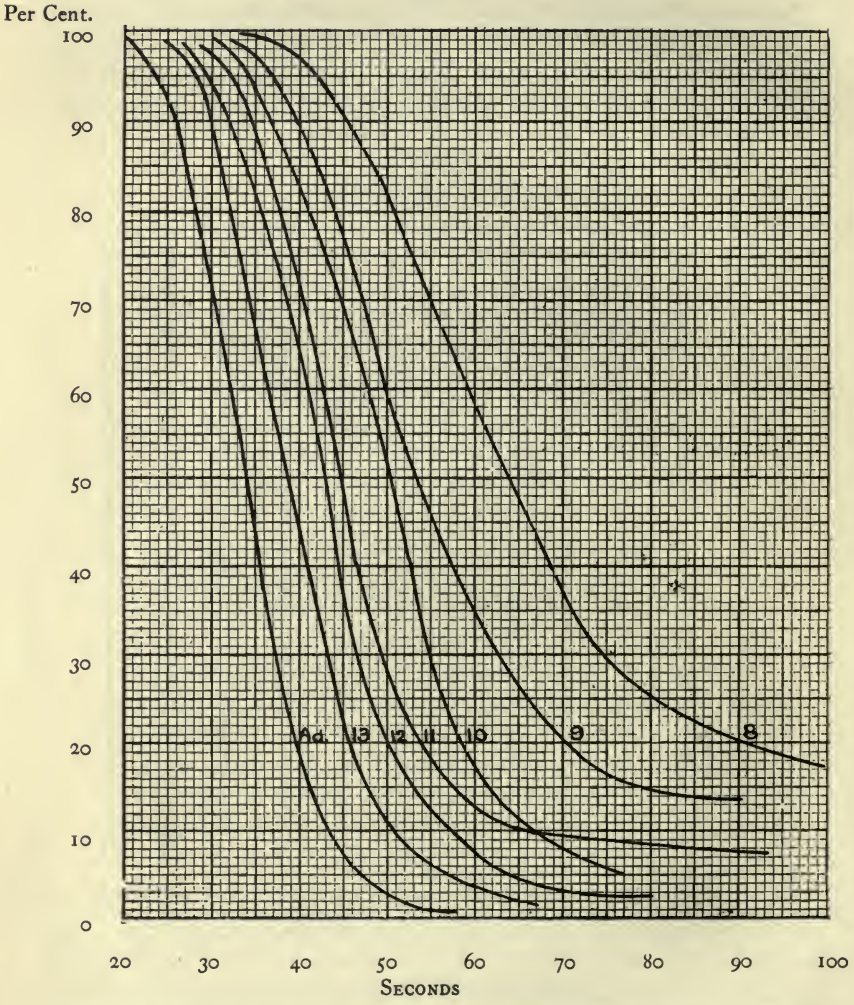
of thirteen year old boys and is the point below which 42 per cent of adults fall.

Each age as used here includes all the individuals up to the succeeding birthday. That is, by the nine year group is meant that year group having a median age of nine and five-tenths years. Various divisions have been used in other works, such as including all as nine years who are between eight and a half and nine and a half years, or including those who are within a month of the birthday. In view of the fact that we are accustomed to

GRAPH III

PERCENTILE CURVES

BOYS

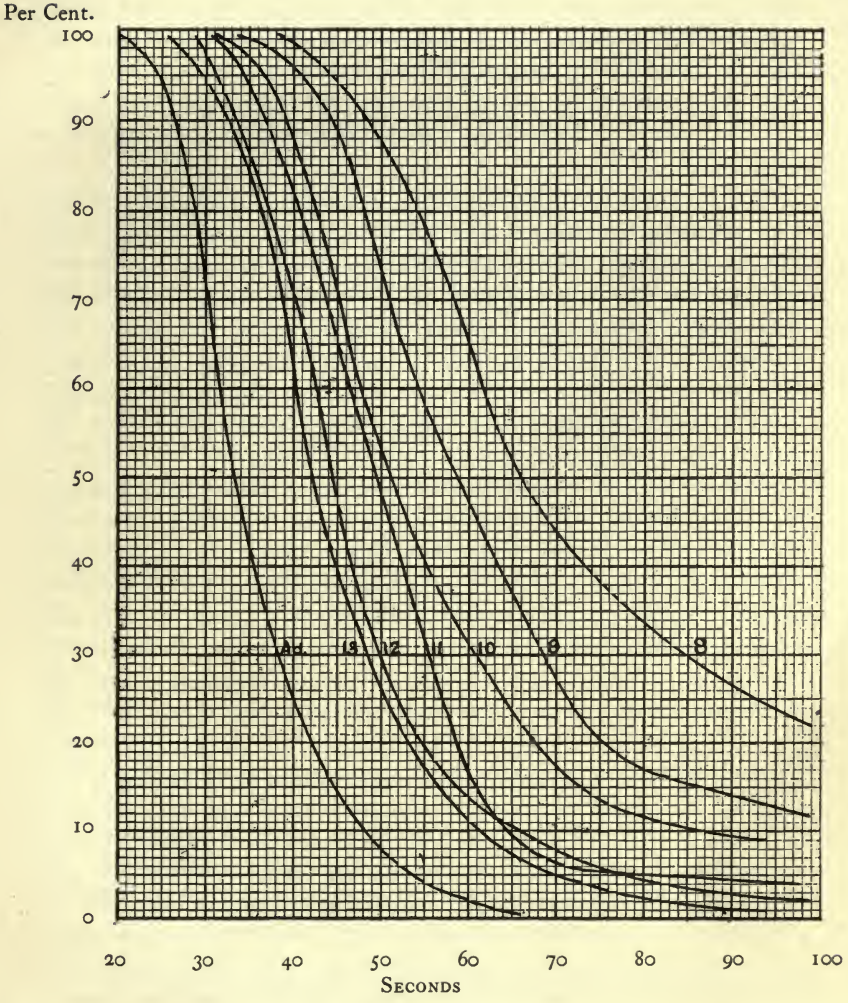


speak of a child as being nine years of age until he reaches his tenth birthday, such divisions often result in a misinterpretation of results. It has therefore seemed advisable to use this grouping and to take half of the cases from the lower half-year and half from the upper, except in the ages seven and fourteen which have been previously discussed.

GRAPH IV

PERCENTILE CURVES

GIRLS



SEX DIFFERENCES

In performance tests more than in any other kind are sex differences to be found. Experimental evidence of this was presented as early as 1900 by Bagley (1) who found that boys gave better results on tests in the psycho-motor field, Wallin (14) and Young (19) find a sex difference favoring boys on the formboard,

while Wooley and Fischer (17) declare the puzzle box to be the only test in which they found a great sex difference, boys being much more successful with this. Mrs. Young (18), in an earlier study of the cylinder test in which she has worked out a correlation with the formboard, has pointed out a distinct sex difference and has attributed it to the fact that the formboard presents a different problem for men and for women. This is equally true of the cylinder test.

This factor can best be observed in our present results by superimposing Graphs 1 and 2. It will be seen here that the minimum line of the boys is below that of the girls except at ten years, where they are equal, and at fifteen, where that of the girls falls below. The lower quartile line for girls falls midway between the lower quartile and median lines of the boys and the median line for girls falls midway between the median and the upper quartile lines for boys up to the age of fifteen. The upper quartile runs far behind for girls up to adult.

While the points for adults coincide at the median, lower quartile and minimum, it is to be noted that the men's group consists of fifty per cent good and fifty per cent poor cases while the records of women are taken from the good group alone, university students. The figures for the women are given in Table 7, page 48, accompanying those of the three groups of men and show that up to and including the median, the women rank above the college men and prisoners and behind the aviation cadets. They are much behind the college men at the upper quartile and maximum which has the effect of making the median and average deviation higher.

Probably the most important factor in producing this difference is the attitude with which the test is approached. Boys and men quite generally show a spirit of competitiveness, attempting to make the best time record that they can. Girls of the upper ages and women attempt to determine how to do the test rather than how to do it the most quickly. They seem satisfied if they do it at all, refuse to hurry, or when they do try to rush, become confused. As a whole, the sexes show a difference of poise when facing a performance test.

IV

QUALITATIVE ASPECTS

If by intelligence we mean "the ability to solve that which for the individual is a new problem," the cylinder test as here presented is not a test of intelligence primarily. In practically all cases, the best trial occurs after the nature of the problem has been learned. If on the first trial, it is because the end to be attained has been seen before the test is actually performed. It does, however, offer a problem to children from six to nine years of age. For children at this stage, the test presents the question, "How can this be done?" Above this age, the question becomes, "How can this be done the most quickly?" To be sure, they may not appreciate the order of the blocks before the third trial, or possibly not at all, but the correct solution they do foresee.

The first trial, then, is a learning trial for one doing the test for the first time, or a relearning trial for one who has done it before. For those ages within which a problem is set, the amount of instruction necessary to enable the child to learn how to perform the task is a measure of the intelligence and it was for this reason that the method of smallest didactic steps was adopted. Can the child grasp the problem when the board is presented to him? If not, can he determine what should be done when told that his solution is not the correct one? Can he find a way of making all the cylinders fit when told that they must be level with the top? Will one successful placement suggest to him the manner of correcting other errors? The qualitative differences between the normal and the feeble-minded appear most strongly here. Not infrequently, especially in the upper ages, the shortest time trial is fairly satisfactory in low grade cases, but the mental status is suggested in any of these by the performance upon the initial trial.

In an article on "The Relation of Intelligence to Efficiency" (16), Professor Witmer presents the proposition that twelve performance scales are necessary to grade and level an individual,

the intelligence level being measured by the invention scale and the resource scale, the proficiency level by the efficiency scale and the operation scale. The general proficiency of an individual is a complex of the efficiency (a term confined to single operations) and the number of operations over which efficiency may be shown. The measurement of efficiency by the cylinder test would require a large number of trials; in confining ourselves to three trials and using the shortest time trial as an index, we are rather making a determination of the competency in this one field of operations, the psycho-motor. Competency is here used in a more limited sense but with the same general meaning as in the above article. By competency in this sense is meant the sum total of all the factors, mental and physical, operative in a particular performance. As Professor Witmer has shown, the effect of competency upon efficiency lies not so much in the ultimate degree as in the rate of its attainment. Using this more limited meaning of competency, it would perhaps be better to say that proficiency is determined by the number of fields of operations in which competency may be shown.

It is in the qualitative aspects that the superiority of the cylinder test lies. Any performance test which is going to withstand the culling that is sure to follow the standardization of a large number, must have features which differentiate it from other tests. The principal advantages possessed by the cylinder test seem to us to be:

(1) Distributive attention may be brought out better in this test than in any other so far standardized. Unlike other factors which may or may not appear, this may always be observed. The one-hand worker, who cannot distribute attention sufficiently to work well with both hands, the individual who uses both hands until a situation arises, when he forgets all about the blocks he is holding in one of them, the one who places a block with one hand while engaged in picking up another to fit a recess in another part of the board, these are types which are brought out clearly by this test.

(2) There are certain steps in performance which seem to appear with increasing age. The distinguishing between Series A and Series B, that is, to tell on which side of the board a given block belongs, or distinguishing the direction of decrease in size in Series C, and again, the estimation of distance on Series C,

these appear in succession with an interval of several years. Children up to the age of ten quite generally try any small block in some C recess and then pass in either direction by adjacent steps until the correct recess is found. At ten, the direction is generally correct, or is quickly corrected. Later there appears a knowledge of the nature of this series, and from thirteen years on, it is quite usual to find an estimation being made of the approximate position both in the placement and in correction. The use of two hands also appears at about the age of nine, being unusual before and usual after that age.

Method also becomes increasingly complex with increasing age. The younger children take the blocks as they happen to pick them up, or even begin to work with the smaller ones. The best children of five or six years work at one recess at a time, taking a block they think will fit, discarding it for one slightly larger until they find the correct one, then go to the next recess and repeat the performance. After age seven, blocks are seldom discarded, but an attempt is made to find where they belong by trial and error. This age finds children placing the upper two series systematically and then filling C at random. Next, the use of logical procedure is continued through C with a tendency to drop away from it before the test has been completed, or with the first bit of trouble in placing a cylinder. Not until the age of eleven or twelve do we find adherence to a system throughout the entire trial. Yet, even with adults, it is quite usual to see these theoretically best methods of solution dropped where there is increased ability due to speed or distribution of attention. Failures to use methods appropriate to the age, therefore, must be interpreted in the light of the entire performance. The fact that they are not used will be less significant often than the positive fact of their use.

This is not meant to be a definite statement of just what occurs at different ages, for the data is insufficient. It is merely meant to point out distinctive qualitative differences that do appear and which suggest that a qualitative standardization, comparable to the standardization of errors in certain other performance tests, can greatly increase the value of this test for diagnostic purposes. An attempt to carry this out along with this investigation resulted only in a determination of the nature of the problem, and the setting forth of the preliminary classifications.

(3) Another advantage of this test is the large number of movements required. Our conclusions regarding the mental processes of a child are drawn from the observation of his behavior, therefore, the more points at which behavior may be observed, that is, the more adequately behavior represents the mental steps, the better are we enabled to form judgments regarding the mental operations.

Young (20) has called attention to the necessity of distinguishing between the real extent of any capacity and the amount that may be brought out by a single test. He has used the words *epideixis* and *hyparxis*, meaning by the former the power displayed on a particular occasion and by the latter the power that the individual is capable of displaying. It is the hyparxis regarding which we desire information and this can only be reached through the epideixis. The nearer the epideixis approaches the hyparxis, the more valuable our test results. The more chances we have of observing any process, the greater the probability of a correct estimation of the hyparxis. The number of possibilities of the repetition of similar situations gives more chance of a satisfactory observation than could be obtained from a test in which but a few moves are made. The number of moves in replacing the cylinders is usually much greater than the minimum, for false placements appear in all but the most careful performances.

V

THE RELATION OF CYLINDER TEST PERFORMANCE TO PROFICIENCY

If our hypothesis is warranted, that the cylinder test is a test of competency in the psycho-motor field and to that extent is a measure of proficiency, we should expect to find a relationship existing between the performance of this test and the proficiency that the individual has displayed. For the investigation of this, three fields have been chosen, school standing as a basis of the study of children, adults of three levels of daily performance, and mechanical or manual ability as shown in shop ratings.

Age-Grade Distribution

The school grade of a child is the only general measure we have of his proficiency. That we speak of a child as being "at age" or "over age" for his grade is evidence that a normal child is expected to be in a certain grade at a certain age. There are many factors tending to nullify this as a measure, not the least of which is the custom of school authorities of retaining a child in a grade higher or lower than that to which his ability entitles him. But taken as a whole, the grade is usually considered as a measure of a child's daily performance.

Tables 5 and 6 give separately for boys and girls the distribution of shortest time trials by age and grade. The first column gives the grade, the second, the number of cases credited with a shortest trial, omitting those included under D. N. C. (Did Not Complete) and Failure of the preceding tables, both of which are included under F. (Failures) in the third column. The mean, average deviation and median of the successful cases is given, with the minimum, maximum and the upper and lower quartiles where the number of cases is sufficiently large to make this at all indicative.

These values differ from those in Chapter 3, where the F. cases were considered as in the poorer quartiles, but for purposes of

comparison of parts of an age group, this is much more concrete. However, this changes the distribution previously given to a negligible amount above the eighth year, except in the cases in the third grade.

It will be observed that for Age 7, the number of failures, the mean, median, A. D., and maximum decrease with increasing

TABLE V

AGE-GRADE DISTRIBUTION—BOYS

Gr.	No.	F.	Mean	A. D.	Min.	L. Q.	Med.	U. Q.	Max.
				Age 7					
1	12	7	86.2	20.7	53	65	78.0	39	137
2	37	14	72.3	18.5	43	58	63.0	74	195
3	5	0	56.8	15.4	41	–	48.0	–	78
				Age 8					
1	6	2	84.7	26.3	43	–	84.0	–	121
2	34	3	70.6	16.3	37	55	68.0	72	152
3	45	3	62.9	13.4	33	51	59.0	69	144
4	6	0	55.3	14.1	40	–	48.5	–	91
5	1	0	49.0				49.0		
				Age 9					
1	1	1	52.0				52.0		
2	20	1	53.9	11.8	31	43	54.5	67	79
3	30	8	54.7	9.6	37	48	51.0	61	90
4	28	3	50.5	8.3	35	43	50.5	60	71
5	4	0	46.8	9.1	39	–	41.5	–	65
6	4	0	40.7	7.6	26	–	44.0	–	49
				Age 10					
1	1	0	53.0				53.0		
2	4	0	55.0	4.0	49	–	56.5	–	60
3	10	3	54.5	11.5	34	–	52.8	–	78
4	46	0	49.8	6.5	32	43	50.5	54	72
5	30	1	47.1	8.3	32	38	47.5	53	72
6	5	0	46.0	8.0	37	–	43.0	–	62
				Age 11					
1	1	1	93.0				93.0		
2	0	1							
3	0	1							
4	23	2	48.2	11.0	32	37	43.2	58	108
5	35	1	42.7	6.0	25	38	42.8	47	67
6	33	0	43.6	6.3	30	39	43.0	51	63
7	2	0	42.0	2.0	40	–	42.0	–	44
				Age 12					
4	7	0	43.7	5.0	35	–	42.8	–	61
5	22	0	43.8	7.2	28	37	44.5	51	66
6	41	0	43.7	9.2	26	37	41.2	48	105
7	21	1	40.0	7.4	26	34	38.2	44	63
8	7	0	47.0	9.4	38	–	41.8	–	65

TABLE V—CONTINUED

Gr.	No.	F.	Mean	A. D.	Min.	L. Q.	Med.	U. Q.	Max.
				Age 13					
4	1	0	38.0				38.0		
5	8	0	40.9	4.4	32	–	40.5	–	50
6	27	1	39.9	7.1	27	34	40.4	46	67
7	32	0	36.3	5.6	23	30	34.5	42	52
8	31	0	38.3	6.6	26	32	37.6	42	64
				Age 14					
4	3	0	37.0	6.0	31	–	34.0	–	46
5	7	0	41.9	5.0	36	–	39.0	–	53
6	24	0	38.2	5.3	23	35	39.0	44	51
7	22	0	40.1	7.2	27	34	38.8	46	61
8	31	0	40.9	5.2	26	37	42.2	45	54
				Age 15					
4	2	0	32.5	3.5	29	–	32.5	–	36
5	1	0	33.0				33.0		
6	8	0	37.6	5.4	32	–	35.0	–	53
7	5	0	37.8	2.2	34	–	37.2	–	43
8	14	0	37.6	4.9	30	32	36.5	40	52

TABLE VI

AGE-GRADE DISTRIBUTION—GIRLS

Gr.	No.	F.	Mean	A. D.	Min.	L. Q.	Med.	U. Q.	Max
				Age 7					
1	12	15	84.0	26.2	49	59	69.0	90	188
2	36	16	80.3	18.2	44	62	75.2	82	205
3	4	0	75.5	9.5	65	–	72.5	–	92
				Age 8					
1	1	4	62.0				62.0		
2	45	6	69.7	13.3	41	58	68.8	81	105
3	24	5	63.1	10.1	46	53	59.5	70	95
4	12	2	56.5	9.6	42	46	55.0	62	91
5	0	1							
				Age 9					
2	5	3	77.2	11.8	55	–	75.0	–	99
3	25	6	54.4	8.4	36	46	54.0	64	69
4	49	2	61.4	11.7	35	48	54.8	70	98
5	7	0	54.0	12.0	33	–	54.0	–	78
6	1	0	74.0				74.0		
				Age 10					
2	1	0	72.0				72.0		
3	5	3	52.2	9.4	39	–	56.0	–	66
4	43	2	51.0	8.7	34	45	48.0	58	75
5	30	2	51.9	11.7	32	43	46.5	60	94
6	13	1	54.2	10.3	39	48	50.0	55	85
				Age 11					
3	5	0	52.4	7.9	33	–	55.0	–	65
4	9	3	51.0	5.8	36	47	51.0	57	60
5	34	0	50.9	11.6	33	40	47.0	59	98
6	47	0	46.7	6.6	30	41	48.2	53	66
7	2	0	53.5	6.5			53.5		

TABLE VI—CONTINUED

Gr.	No.	F.	Mean	A. D.	Min.	L. Q.	Med.	U. Q	Max.
				Age 12					
3	1	0	69.0				69.0		
4	6	0	57.7	17.9	40	–	47.0	–	96
5	21	1	49.2	10.7	33	39	44.0	54	85
6	38	0	44.4	6.9	29	38	45.5	49	79
7	27	0	47.0	11.0	29	39	43.2	52	99
8	6	0	42.8	8.2	29	–	43.5	–	54
				Age 13					
3	1	0	50.0				50.0		
4	5	0	51.0	11.2	37	–	46.0	–	65
5	8	0	44.0	7.0	36	–	41.0	–	65
6	23	0	46.0	9.2	28	36	48.6	53	74
7	41	0	46.7	10.1	27	39	42.8	49	94
8	21	0	41.9	7.4	25	36	39.9	46	63
				Age 14					
4	2	0	57.0	15.0	42	–	57.0	–	72
5	5	1	43.4	7.8	36	–	39.3	–	63
6	13	0	44.5	7.9	30	37	47.0	53	55
7	16	0	47.9	9.5	33	38	44.5	57	98
8	42	0	41.1	6.0	27	36	41.3	47	65
				Age 15					
5	3	0	44.2	6.7	34	–	49.0	–	50
6	9	0	42.6	12.4	28	–	37.2	–	93
7	8	1	50.5	10.1	38	–	47.0	–	77
8	21	0	45.5	10.9	26	36	12.0	50	78

grade. The decreasing proportion of failures is particularly significant. The Age 8 distribution shows a decrease in the percentage of failures with increasing grade and a decreasing mean, median, A. D. and quartiles for both sexes. In Age 9, the third grade boys, whom we may consider "at age," show to disadvantage as compared with the second grade boys, there being a marked increase in the number of failures. Those in the fourth are better throughout and the fifth and sixth grade boys are still better. In the girls' group, with the exception of the single case in the sixth grade, there is an increase in ability with increasing grade, though the fourth grade girls do slightly worse, other than in failures, than the third grade girls. The Age 10 boys show a steadily decreasing time and failure distribution, particularly favoring the sixth grade. The girls of this age show a similar distribution, with the exception of the sixth grade, where their performances are poorer than in either of the two preceding grades. The next age shows the same general tendency, but with the exception of a slight advantage favoring the fifth grade over the sixth grade boys. In this group, the two year advanced boys give the best

results but the girls do poorly, though there are only two cases of each. The same tendency appears in Age 12 as in the previous ages, but here, for once, the girls who are two years in advance do better while the boys of that grade do poorer work than the "at age" boys. From this point on, the evidence is not so conclusive, though there is a general tendency favoring the "at age" as compared with the one year "over age." But the "above age" do not do so well and those several grades behind show up to better advantage than in the younger years. This is probably to be attributed to the higher specialization in the upper grades, where intellectual abilities are demanded and where the capacities brought out in this test are not so important.

The tendency of these distributions shows, then, that there is an increase in cylinder test performance with increasing pedagogical age, which is the best measure we have of the general proficiency of children. A similar correspondence between pedagogical age and mental test results was found by Stern (11) with the Binet Scale and by Humpstone (4), who found that the number of pupils successful in repeating a given series of digits increased with each successively higher grade.

Adult Performances

The three groups of adults used in Chapter 3 represent three grades of proficiency. That the inmates of our penal institutions represent a low grade of proficiency need but be said. Some of them have been engaged in branches of crime in which they have shown themselves to have ability which, rightly directed, would have made them successful in the business world and the accidental criminal is often a man of good mental ability, but these cases are few. Basing an estimate upon a previous investigation of the writer (5), one-fifth of the prisoners would be comparable in intelligence to a college group and would fall almost entirely within the lowest quartile of the latter. It is generally conceded that a college group ranks higher in general proficiency than a non-college group picked at random from normal individuals of the same age. A more proficient group than that of the men from the Aviation Section of the Signal Enlisted Reserve Corps, in training at an army aviation field, is not readily available. The mental and moral examination for entrance is most rigid, past performances in school and business being given considera-

tion in connection with the decision as to mental ability. There are some, it is true, whom we would not class as among the highest in proficiency, but by far the greater number would fall within the highest quartile of the college group used in this study.

The distribution of the shortest trial performances of these three groups is given in Table 7, and in it is included that of university women, which was used in the discussion of sex differences in a previous chapter. The lower quartile, median and upper quartile, as well as the less reliable mean and the mode, place the aviation cadets first, the college men two seconds behind (and two seconds is not an inconsequential interval where fifty per cent fall within seven seconds), while the prisoners trail far in the rear. The better half of the women rank above the better half of the college

TABLE VII

DISTRIBUTION OF PERFORMANCES OF ADULT GROUPS

	College Men	Aviation Cadets	Prisoners	College Women
No. of Cases	123	54	791	154
Mean	33.3	32.0	38.1	35.4
A. D.	4.6	4.8	7.5	7.2
Mode	34(31)	32(29)	37	32
Minimum	20	22	18	18
L. Quartile	30	28	31	29
Median	34	32	37	33
U. Quartile	37	35	44	41
Maximum	51	46	115	66

men, but as in the case of the prisoners, the frequency of poor performances in the slower half causes the mean and upper quartile to be much poorer than those of the other two groups. The figures for the prisoners might have been improved slightly had the test been given to every man who entered during the period of gathering this material, but it was many times omitted in those cases in which the performance ability was shown to be good by other tests, when time could not be taken to give tests not essential to that particular examination.

A comparison of these figures leads us to the conclusion that there is, in general, a direct relation between proficiency, as judged by the level of daily performance, and cylinder test performance among adults.

Correlation with Shop Rating

This investigation was the outgrowth of the observation at the Indiana Reformatory that many men, particularly of the colored race, whose mental age according to the Binet Scale was so low as to indicate that they were seriously deficient mentally, were nevertheless successful in the performance of quite complicated shop tasks. A tendency of the results of the cylinder test to give a higher rating in these cases than did the Binet Scale, suggested a comparison of such results with shop ability.

Eight shops of that institution were chosen for this study, in each of which the men are received in most cases without previous training, to be taught the trade. The instructor in charge of each of these shops was asked to name his most skillful workman, the poorest workman, the next in skill, the next poorest, and then the shop roll was examined to find men who could be placed between these two extremes in a rank order.* All men were eliminated from consideration who were not giving consistent effort, thus confining the ranking to a basis of skill and efficiency. Ten men were so rated in each of the shops, except the tin shop, where eight men were reported.

Table 8 presents the correlation between this rank order and the rank order of cylinder test performance, according to the method of Rank-Differences, as presented by Whipple (15).

Assuming that the cylinder test measures that ability which is demanded in manual or mechanical work, a correlation with shop ability is the best experimental means of determining which method of scoring is the most valid. For this reason, there have been included in this table the correlations of this shop rank with the first trial, the second trial, the shortest of three trials, the average of three trials and the average of the last two trials.

Before the correlations had been computed, the shops were arranged in the order in which mental ability seemed to be demanded. That is, it has been the belief of the officials of the institution that the demands made upon intelligence were greater in the foundry moulding room than in any other shop, with the tin shop a close second and the tailor and shoe shops following with practically the same rating. Men may be placed in the

*The writer is indebted to Mr. C. P. Stone of the Department of Research of the Indiana Reformatory for this rating and the tabulation of the cylinder test records of these men.

TABLE VIII

CORRELATION OF CYLINDER TEST PERFORMANCE WITH SHOP ABILITY

Indiana Reformatory

Shop	Trial				
	First	Second	Short	Av. of 3	Av. of 2
Foundry (Moulding)	—.18	+.36	+.57	+.05	+.36
Tinning	+.08	+.29	+.44	—.31	+.23
Tailor	+.55	+.58	+.69	+.81	+.51
Shoe	+.32	+.64	+.72	+.33	+.68
Cabinet	—.07	+.07	—.11	+.16	+.23
Barber	—.06	+.22	+.33	—.14	+.46
Foundry (Grinding)	—.33	+.04	—.13	—.44	—.01
Broom	—.48	+.03	+.15	—.02	+.05
Average	—.02	+.28	+.33	+.06	+.31

grinding room without any requirements as to intelligence, while the broom shop is made up of the physically and mentally incompetent.

A perusal of this table shows that the first trial gives negative correlations, except for fairly high positive correlations in the tailor and shoe shops. This trial is the only one to give a negative average correlation, it being —.02. The second trial gives positive results throughout, with the upper four shops giving much higher correlations. The average of this trial is +.28. The shortest trial, except for the cabinet and grinding departments, gives a positive correlation higher in each shop than that of any of the other bases of scoring. The shoe and tailor shops have a correlation of about .70, while the foundry moulding and tin shop follow with .57 and .44, with the barber shop giving .33. The average of three trials gives both high positive and high negative correla-

tions. It furnishes the highest positive, +.81, and the highest negative result, —.44, the eight shops having an average correlation of but +.06. The average of the last two trials gives results following closely upon those of the shortest trial. In the upper four shops, it falls distinctly below the shortest trial and slightly below the second trial, but in the lower four shops it gives twelve points higher correlation, except in the broom shop. Its average of +.31 is but two points behind that of the shortest trial.

The probable errors for the shortest trial correlations are,— Foundry Moulding, .15; Tinning, .20; Tailor, .12; Shoe, .11; Cabinet, .22; Barber, .20; Grinding, .23; and Broom, .22.

There are several factors which have their effect upon the correlation. The length of time in a shop will work to the advantage of the older men in determining their shop rating. The man who has been in a shop for four years will, of course, be more skillful than one who has been in the shop but a year, and the extent to which the rate of progress has been taken into account in forming the rank order, there is no means of determining. This is but one of the ways in which the personal equation of the instructor affects the correlation. The fact that the men are not all engaged in the same operations within a shop is of importance. Some men who are highly successful as moulders when working upon one pattern, find another almost impossible, yet the tasks are sufficiently similar to warrant a rank order. The miscellaneous character of the broom shop and grinding room men makes any figures based upon their rating of doubtful value. Regardless of these things, the controlled environment and the close observation of the workmanship through a prolonged period, makes this an especially valuable source of material for such an investigation.

This study supports our previous argument that the shortest trial is the best measure of performance or psycho-motor ability. It further indicates that there is a positive correlation of rather high proportion between the cylinder test performance and manual or mechanical capacity.

VI

SUMMARY

The conclusions that have been reached in the consideration of performance tests in general and the cylinder test in particular and in the experimental investigation reported herein, may be summarized as follows:

1. An understanding of the capacities and the disabilities of an individual, a complete clinical picture, requires an investigation into those powers which have been variously termed manual ability, motor ability, performance ability and psycho-motor capacity. Intelligence tests tend to place too great emphasis upon the ability to use language, hence they give a false impression of the mentality of the less favored, the deaf, the illiterate or those with language defect.

2. The Witmer Cylinder Test is a performance test which possesses those qualities necessary in a piece of apparatus for measuring this ability: (1) a qualitative difference in performance, (2) a series of graded stimuli, when used in connection with the individual blocks of cylinders of Dr. Montessori's didactic material, (3) applicability to a wide age range, (4) a uniform method of procedure for all ages and (5) an absence of factors favoring language ability.

3. This test has both qualitative and quantitative aspects,—it tests at the same time two different things. Qualitatively, the first trial tests the ability to make an adaptation to a new problem and is sufficiently complicated as to permit the differentiation of subjects, especially in the years of childhood. Quantitatively, the series of trials gives a measure of psycho-motor capacity.

4. The shortest of three trials gives the best time index of this particular mental factor.

5. There is a decrease in time of performance with increasing age.

6. There is a distinct sex difference in the time required to perform the test, favoring the boys. This is largely due to the dif-

ference in attitude and poise and to the fact that it sets a different problem for men and for women.

7. The cylinder test is peculiarly adapted to the determination of the degree of distributive attention of an individual.

8. There is, in general, a direct relation between the cylinder test performance and pedagogical age, which is the only measure we have of the proficiency of children.

9. Differences of proficiency of adults, based upon the level of daily performance, are accompanied by differences in psychomotor capacity as measured by the cylinder test.

10. A positive correlation is found between manual skill and efficiency as measured by shop rating and the performance of the cylinder test.

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