Anaysis of the skilled performance of mentally deficient adults

Slupinski, Leon

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LEON SLUPINSKI

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ANALYSIS OF THE SKILLED PERFORMANCE

OF MENTALLY DEFICIENT ADULTS.

CONTENTS.

LIST OF PLATES.

ABSTRACT.

It was observed that mental defectives, who were unable to draw a diamond, revealed an associated decrease in their performance time and increase in hand pressure.

Closer study of the failure to execute a diamond suggested the hypothesis that the chief difficulty consisted in the patient's inability to draw the obtuse angles, i. e. to make that particular angular change in the direction of the moving hand.

Subsequent experiments confirmed the close relationship between the ability or inability to draw a diamond and the drawing of an obtuse angle. Various degrees of difficulty involved in drawing of different angles were also demonstrated. These experiments also indicated that patients with an I. Q. below 38 could not draw an obtuse angle or a diamond, while subjects with an I.Q. above 57 could.

The main experiment consisting of a battery of tests was carried out on two groups of defectives and a third group composed of nursing staff. The I.Q.'s of both groups of defectives varied between 38 and 57. The subjects in the first group could not while those in the second group could draw an obtuse angle.

The results of the main experiment showed a significant difference between the means of the three groups for Simple Reaction Time, Pressure and Performance Time tests. There was also a significant difference between the means of verbal and practical tests of both groups of defectives. In all three groups positive correlation was established between the Pressure and Performance Time tests.

On the whole, drawings, as other skilled performances, were shown to depend on the ability of the individual to maintain and vary direction and pressure, and the correct timing of these activities. These three factors would appear to be the essential components of skill studied.

C H A P T E R I.

S K I L L.

Everyone would probably agree that driving a car, piloting an aircraft, swimming, playing a game of football, or piano playing require some degree of skill. These performances are mastered by some people after varying degrees of effort and different periods of training. Other people, although physically healthy, are unable to attain the necessary level of efficiency in these skills and the reason for their failure are still obscure and often expressed only in very general terms without a reasonable degree of precision.

Let us have a closer look at these, apparently different, skilled performances and make an attempt to find some common denominator in all of them.

A driver of a car is required to keep or vary its direction and speed according to the road surface, inclination, bends, and also other traffic, signals, etc. The direction and speed of a car seem to be related: any considerable change in direction would require some decrease in speed. The direction and speed of a car are indirectly effected by the pressure of driver's limbs on a steering wheel and accelerator; this pressure is directly caused by the contraction of appropriate muscles. There is another important factor which has to be considered when we analyse the driving of a car, namely timing. The concept of timing seems to be somehow ambiguous and it is often used to express one phenomenon or a variety of phenomena. By timing is meant explicitly the beginning of any muscular acivity; implicitly it may mean the time of the preparatory set for action or the time interval between the beginning and the end of one reaction. It may also mean the performance time, if we are dealing with the time interval for the skilled performance as a whole or with a distinct part of it. The difference between the reaction and performance seems to be as follows: a reaction occurs when some muscular activity is involved such as the maintenance of direction or speed. Where there is variation in this activity leading to change of direction or speed we may talk of performance. On the whole performance consists of at least two or more successive reactions. The relationship between the beginning of any activity, and the timing of its various components, may be close, but it may also be very loose. A car driver may begin some action at the wrong moment, but the action itself may last the correct length of time and the vice versa; the lag-time between the two successive reactions may be the correct one, but may also be too long or too short. After this brief analysis of car driving performance it seems to be possible to isolate three main factors. i.e. maintaining and making necessary variations in direction, speed and timing. Interplay between these three could determine the degree of efficiency in car driving performance.

A pilot of an aircraft has a similar task of keeping and varying direction and speed of the aircraft, chiefly according to the indication of instruments, he has also to time perfectly all his actions. Maintaining and varying the direction and speed of the aircraft is effected by the pilot exerting pressure on the appropriate levers as a result of contraction of his muscles.

If we compare these two performances, i.e. driving a car and piloting an aircraft, we find that there is an essential similarity between them, because a car driver and a pilot are concerned with the keeping and changing of direction and speed of their respective machines, and they have to time correctly their actions which are indirectly effected by the pressure of their limbs on the controls and directly by the contraction of their muscles. There are, however, some differences between these two performances, which seem to be not of primary importance. The direction of a car has to be maintained and varied in one horizontal plane, while the direction of an aircraft has to be maintained and varied in not only the horizontal but also the vertical plane; there are also some differences in the range of speed of both machines. As far as timing is concerned it is probably the case that the pilot should be more exact than the driver, moreover, in piloting an aircraft there is definitely a wider range of stimulation to cope with than in driving a car.

In swimming there is also maintenance and variation of the direction and speed of the body. This is effected by the coordinated action of the hands and legs of the swimmer due directly to the contraction of his muscles.

In playing a game of football a player has not only to maintain or change the direction and speed of his body, but he has also to control the direction and the speed of the ball. Both these actions are effected by the appropriate degree of contraction of the muscles. The sequence of his actions has to be well timed. The range of stimulation is very wide and all his actions have to vary accordingly.

In playing a piano a performer has to maintain and vary direction and speed and the pressure of his hands on the keyboard. There is also some action of his leg involved. Timing in any good musical performance has to be almost perfect.

In all these skills, i.e. swimming, playing a game of football and piano playing, where the performance is directly executed by the muscular activity, there is also a definite relation between the direction and the speed: any angular change in the direction, whether of the body or of the limb, would require a decrease at the same time in speed.

In all these, apparently different, skilled performances, the presence of the three factors could be clearly observed, i.e. maintence and variation in direction, speed and timing. If anyone of these would for some reasons be deficient, the whole performance is bound to be imperfect. Each of the three factors presents various degrees of difficulty to different individuals in the process of learning some skill. Even when a high degree of proficiency is already attained by a subject, preoccupation with the execution of one particular item, let us say direction, would cause the performance as a whole to lose its 'fluidity' and high degree of perfection. Although we have been dealing up to now with three distinct elements and their variations, present in any skilled performance, it is possible to trace them further back to one common denominator, i.e. a muscle, by which all these are executed. Although force, time, speed, sequence and the degree of the contraction of muscles vary in each of the just described performances, they are always present in any one of them. The contracting muscle may determine performance indirectly as in the driving of a car or piloting an aircraft, or directly as in playing games, swimming etc., but it is impossible to imagine any physical skill without the presence and activity of muscles. We can conclude that a study of any skill should be followed up and enlarged by the study of the activity of the muscles involved.

After these preliminary observations we can pass now to the further analysis of the three essential components of skill and their dependence upon muscle contractions.

1. Direction.

It seems probable that the maintenance of direction is made possible primarily because of the symmetry of the human or animal body. When a human being or animal is moving along a straight line, no matter with what speed, an alternating muscular activity of equal extent is taking place in the symmetrical parts of their bodies. The maintenance of direction of the moving limb seems to be due to the interaction between opposite groups of muscles, i.e. agonists and antagonists. Any change in the direction of the moving body would involve an increase of muscular activity in one symmetrical part of the body with the simultaneous decrease of this activity in another part.

The change of direction of the moving limb seems to be determined by changes in the interaction between agonists and antagonists. The degree of the change in direction, whether of moving body or limb, seems to be directly proportional to the difference between the extent of muscular activities in the symmetrical parts of the body or the differences between the activities of agonists and antagonists. Although the maintenance and change of direction are chiefly effected by the muscular activity, there are also some other contributory factors such as vision and sense of equilibrium which play an important role in the directional adjustments. A blind person can be taught to maintain or change the direction of his body or limbs in a more or less imperfect and limited way, but a person with affected semicircular canals will almost certainly fail to do this.

Maintenance and change of direction are not such easy tasks as they would at first appear, and they can be temporarily or permanently impaired. The difficulties in linear adaptation can be readily observed and studied in the motor behaviour of very young children, defectives, patients suffering from nervous injuries or diseases, people affected by alcohol, and also by observing any skilled performance in the process of its learning. Some of these difficulties are overcome as is seen in the maturation of growing children, some of them seem to be permanent as in the case of defectives and people with nervous injuries, some can be mastered only to certain extent or for a limited number of skills.

Even by observing a perfectly normal subject when he is drawing a series of straight lines or obtuse angles in quick succession, this difficulty of keeping and changing the direction of the hand is immediately obvious to the observer. If we compare the two following tasks, i.e. maintenance and change in direction with regard to the difficulty involved, it seems that any change is much more difficult than the maintenance of direction, and also that keeping and changing direction of a limb is more difficult than the change and maintenance of the direction of the body as a whole.

The last mentioned difficulty with regard to the movements of the limb is probably connected with the curious phenomenon which can be defined as 'the dominance of flexors'. Let us explain more fully the above mentioned concept. The posture of an infant or senile person shows invariably the marked tendency towards fkexion, the most striking example of it is 'the grip reflex' of an infant or the bent posture of an old man. In these cases, the motor mechanism seems to be as follows: a greater number of flexors muscle fibres are active, whether at rest or during the movement of the body or limb, than the number of muscle fibres belonging to the extensors. This apparent tendency to engage, involuntarily, more muscle fibres in the flexors than in the extensors, whether at rest or during movement, could be called 'the dominance of flexors'.

If the execution of the direct movements or angular changes of the limb direction are determined by the harmonious interaction between flexors and extensors, then any permanent residual force existing in one group of muscles only is bound to interfere with the correct execution of these movements. This is particularly true if some precise movement is required, when only few muscle fibres are engaged.

The dominance of flexors seem to be partly overcome in the course of maturation in normal children, but the extent of this achievment varies and, most probably, contributes decisively to the degree of skill acquired in later life. This phenomenon seems to be kept in abeyance during the long period of our active life, but it appears again in senility, due probably to some physiological changes, and results in a marked deterioration in physical skill among aged persons. Some mental defectives never overcome this dominance of flexors and, as can be demonstrated experimentally, they are unable to maintain or change the direction of their limbs correctly.

2. Speed, Force and the Pressure.

Let us now in turn deal with speed and problems related to it. The keeping and varying of speed is effected by the contracting muscle, indirectly as in driving a car or piloting an aircraft, or directly as in playing games, swimming, etc. The speed of simple movements of the body or limbs can be measured with reference to some fixed points or planes. Speed seems to be primarily determined by the speed of muscle contraction, which varies in different individuals, but it is necessary at this stage to introduce another important factor, i.e. force, which is closely related to speed. The amount of force is determined by the number of muscle fibres involved and speed of their contraction. In the majority of human or animal performances both these factors, i.e. number of muscle fibres and the rate of their contractions are engaged in any increase in the speed. It seems that these two concepts, i.e. speed and force, as far as the human or animal motor mechanism is concerned, remain directly proportional to each other.

Let us now go a step further in the analysis of muscle activity. When some movement of the body or limb is executed, there is always shortening of the appropriate muscle fibres although the tension in them remains the same throughout the whole movement. This type of activity, where there is some shortening of muscle fibres with constant tension in them is known as isotonic contraction. There is, however, another type of muscular activity where there is no shortening of muscle fibres as, for example, when some load is applied to one end of the muscle, or where the maintenance of constant pressure of the limb on some surface is required as, for instance, the steady pressure of the foot on an accelerator pedal during car driving. Such muscular activity is characterized by a considerable increase of tension within the muscle fibres, although there is no shortening in their length. This type of muscular activity is known as isometric contraction. In connection with this latter type of muscular activity we can introduce a new concept, i.e. pressure. Pressure can be defined as the application of force to some surface. Its amount is directly determined by the number of muscle fibres engaged and the dimensions of the surface to which the pressure is applied. The type of muscular activity involved in the application of pressure may be isometric contraction when there is no movement, as for example, the pressure of the leg to the car's accelerator, or it may be a combination of isometric and isotonic contractions where movement takes place, as for instance in the simple performance of drawing a straight line. One the whole, pressure seems to be closely related to force because in both of them the dominant factor is the same, i.e. the number of muscle fibres involved. They both, however, may differ so far as the type of muscular activity is concerned: in the former it is predominantly of the isometric type, while in the latter it is of the isotonic type. There are also some further differences between them: the degree of force depends ultimately on the speed of muscle contraction, while pressure depends on the size of the surface to which it is applied. It seems, that in any type of skilled performance there is an interaction between speed and performance and they both are effected by the isotonic type of muscle contraction. In some performances, however, pressure may come into the picture as well, and there may be an alternative display of two distinct types of muscular activity, i.e. isotonic and isometric.

After this brief description of speed, force, pressure and their possible relationship and also after an indication of their primary physiological determinant, i.e. muscle and its two types of contractions, we may safely say that the degree of perfectness of any skilled performance would be decisively influenced by the harmonious interaction of these factors.

Let us now go another step forward and consider the various degrees of difficulty which these skill-components obviously present to different individuals in the process of mastering some simple skilled performance. Analysis of various skilled performances seems to indicate that the maintenance of constant speed, force or pressure, whatever their extent may be, is a more easy task to an individual than the performance of the correct variations in them, however, there is a definite relationship between these two. If we design two experiments: the first one measuring the subjects's exertion of force and pressure whilst they remain constant, and the second one exploring the ability of the subject to vary them, we shall find that there is an inverse relationship between the amount of force or pressure used in the first experiment and the ability to vary them in the second, this means briefly: that the more the subject uses force or pressure initially the less he is likely to be able to vary them correctly subsequently. Some further explanations are necessary at this stage. Young children and also adults when learning a simple skill usually employ more force and pressure than necessary; this excess of force or pressure is gradually reduced, due probably to maturation and practice in children, and due to practice alone in adults. The extent of this reduction of force or pressure, seems to be predetermined by some innate factors. Some of these problems, particularly pressure, have been already explored experimentally at the lower end of intelligence scale, and results show that the less intelligent subjects exerted more pressure during the simple drawing performance. This relationship probably breaks down in some cases at the upper end of the intelligence scale.

In summing up, it may be said that speed, force and pressure are effected by the various types of muscle contractions, they are interrelated, and they are essential components of skill.

Their interaction would determine the degree of perfection of the skilled performance. Speed, force and pressure seem to be primarily determined by some innate factors and because of that they can be improved to a certain extent only by practice.

3. Timing and problems related to it.

Let us now consider a very complex and ambiguous concept expressed by the term timing. It can be observed and studied in any action involving muscular activity.

As said before, timing means explicitly, the initiation of any muscular activity. It is essentially a mental process, but its execution depends entirely on muscle. It remains in some relation to the incoming stimuli although this relationship may vary considerably. In the majority of the laboratory experiments when a definite stimulus is given by the experimenter to the subject, he reacts, but his timing is chiefly determined by the experimenter. On the other hand, when the stimulus is not definite, as for example in changing the direction of a car when overtaking, increasing the speed of an aircraft, passing the ball, etc., there is always some marginal time left to the decision of the car driver, the pilot or the player, respectively. They may initiate their actions a fraction of a second sooner or later, this would probably not affect the performance much as a whole, but it would certainly affect the perfection of it. It seems that the time to initiate any muscular action as a part of skilled performance is determined by the judgment, anticipation and experience of an individual. These last three factors are intimately related, and, most probably, the two former are the effect of the latter.

In any motor process where timing is involved there is always some time lapse between the stimulus or stimuli, whether extero or entero-ceptive, and the subsequent muscular action. In that interval of time, most probably, mental and motor integration is taking place. This preparatory time interval seems to be dependent on the complexity of stimulation, practice and the intelligence level of the subject. If we exhibit a single stimulus to which the muscular response required is very simple, then this preparatory time would be relatively short, but with the increase of complexity of the stimulation or with an increase in the number of responses required the preparatory time would also increase. By practice this time interval could be considerably reduced, but the extent of this improvement would ultimately be determined by the intelligence, which can be considered not only as the capacity to learn but also as an ability to integrate.

If we use a definite stimulus affecting one sense only where the required motor response is uniform and simple, then we are dealing with some particular instance of timing, namely with the Simple Reaction Time. S.R.T. is probably determined by the perceptual processes and by the speed of contraction of some particular muscles. There is no experimental evidence that it is affected by the age of the subject. As both determinants of the S.R.T., i.e. perception and speed of muscle contraction, are essentially innate factors, this can be only a little improved by practice. S.R.T. seems to be only partly related to intelligence as it is measured by the conventional verbal tests. The relationship is most obvious when we deal with low and middle grade imbeciles, above that level this relationship becomes inconsistent and some low grade feeble-minded show better S.R.T. than s.c. normal individuals. There are good reasons to believe that at the upper end of the intelligence scale there are also wide variations between S.R.T. and the intelligence in certain individuals.

A reaction occurs when some muscular activity is involved such as the maintenance of direction, speed, force and pressure. The time interval between the beginning and the end of any simple reaction seems to be determined by two factors, i.e. by practice and by the innate propensity of the muscle. There can be very little doubt that the time of any muscular action could be improved by practice, but the extent of this improvement is predetermined by the speed with which the muscle fibres are contracted. There seems to be wide variations in the 'reactivity' of different individuals, these differences are difficult to observe in ordinary everyday life, but they come immediately to notice when the learning of some skill is involved. It seems to be possible to put forward an assumption, although it is difficult to prove it experimentally, that this 'reactivity' decreases with age, particularly when a large number of muscle fibres are involved in some muscular action.

As the performance consists of two, at least, successive reactions, performance time would be the sum of their times plus the time interval involved in the change of direction, speed, force or pressure. The performance time would depend similarly on the reaction time, on practice and on the innate propensity of the muscle, but there is also another essential factor which comes into the picture. The time interval between two subsequent reactions, in which change of direction, speed, force and pressure take place, is of utmost importance to the time of the performance as a whole. Any variation in speed, force and pressure would require an increase or decrease in the number of muscle fibres employed, this operation seems to be simple enough, but the switch to the correct volume is much more difficult. A subject usually employs too many or too few muscle fibres and there is always some lapse of time before the required volume is reached. The whole problem is much more complicated when any angular change is required because speed, force or pressure have to be considerably reduced at the same time. Let us take a simple example. When a young child or defective subject was asked to draw an obtuse angle, he drew one line and then he came to a very long stop before he was able to turn his pencil, more or less incorrectly, in the required direction. This long stop between two subsequent reactions is bound to increase the performance time. It can be demonstrated experimentally that there are wide variations in the drawing performance time among normal subjects, which are, most probably, decisively determined by the difference in the time in which change of direction is effected.

After these considerations of various skilled performances, their common determinants, their relationships and the role of muscle, we may attempt to define skill as an ability to keep and vary direction, speed, force and pressure, and to ensure correct timing of these activities. In this broad frame we can fit in almost any skilled performance and study its components and their mutual relationships. The level of skilled performance depends on the complexity of stimulation involved and the number of responses required.

The most simple skilled performance would be composed of, at least, two separate reactions where variation in direction, speed, force or pressure are present.

For the further study of skill we have chosen a very simple performance, the drawing of various angles and diamonds by subjects at different levels of intelligence. As has been already mentioned, all factors in any skill are essentially innate and can only be improved to a certain extent by practice. The drawing of various angles is a simple performance where very little practice is involved, and, therefore, innate factors come out more distinctly. These drawings involve all the essential components of skill as it has been defined above, it is necessary while drawing to maintain and vary the direction of the moving pencil, its speed and pressure.

There is also another reason why we have chosen the drawing performance as the object of our investigation, i.e. relative absence of fatigue, which can complicate considerably the study of any repetitive, prolonged skilled performance.

CHAPTER II.

PRIMARY OBSERVATION AND TESTS.

Slightly more than fifty years ago Binet observed that young children and also some mental defectives were unable to draw a diamond. Since that time there have been some more or less inadequate explanations of this phenomenon, based chiefly on the perception, i.e. failures in the perceptual field were held as responsible for the failures in drawing a diamond.

There seems to be, however, another possible approach to this particular problem. Observations of drawings performed by mental defectives and also experiments described in this work appear to indicate that the failure to draw a diamond can be explained in terms of temporary or permanent deficiency of the human motor mechanism. This arrested motor development is manifested not only in drawings but also in any type of skilled performance.

1. Primary observations and basic assumptions.

It seems to be necessary to describe fully the first observation which gave an impulse to the present work.

Some time ago one of the mentally defective patients was tested on the Revised Stanford-Binet Intelligence Scale, Form L. When he was asked to draw a diamond his first attempt was unsuccessful and he drew a triangle instead of a diamond. There was nothing unusual about that, as it had happened many times before with other patients; but his whole behaviour during the drawing was somehow peculiar and it attracted the attention of the writer. When he came to the second attempt to draw a diamond, and particularly when he approached the turning point or an obtuse angle within the diamond, his movements became very slow, pressure of the pencil on paper visibly increased and finally he came to a complete standstill.

After some moments he moved his pencil again, not slightly down and to the right as an obtuse angle would require, but to his right, drawing an acute angle. Then he lifted up his pencil and made another straight line from the initial point, thus drawing a triangle again. When drawing, his face became covered with beads of perspiration and especially at the turning point his facial expression showed every sign associated with acute discomfort. The same thing happened during his third and final attempt.

On the basis of these observations, the three following assumptions were formulated:

a) Failure to draw a diamond is determined by the failure to draw an obtuse angle.

b) Failure to draw an obtuse angle is due to motor disability, i.e. to make this particular angular change in the direction of the moving hand.

c) Inability to draw a diamond is somehow connected with an increase in the pressure of the pencil on the drawing paper, and also with the considerable decrease in drawing performance time.

The primary assumptions seem to indicate the possibility of research, particularly an investigation of ability to make angular changes in the hand direction, pressure exerted by the hand, drawing performance time and the relationship, if any, between these.

2. Study of record forms previously completed.

Before designing experiments in order to verify the first of our three basic assumptions, all available record forms were checked and in no one case did an attempt to draw a diamond, no matter in what geometrical form this was recorded, contain a correctly executed obtuse angle. This seems to confirm the first assumption.

It was also possible to observe on these record forms that some figures were drawn with considerable pressure of the pencil on the paper. This observation seems to confirm the first part of our third assumption.

The study of failures to draw a diamond on the already completed record forms revealed that, instead of drawing an obtuse angle within a diamond, some patients drew an acute angle, thus drawing a triangle, some others drew a right angle completing thus a rectangle or a square, the others drew some geometrically unidentified figures where instead of angles were curves or 'rounding up'. Even those patients, whose drawings were almost correct, often drew a diamond using four separate pencil strokes.

It seems obvious that various changes in the direction of the moving hand, required when drawing various angles, present different degrees of difficulty for individual patients. This last observation seems to have some connection with the second of our three basic assumptions.

Preliminary experiments.

In order to explore some aspects of drawing problems in an experimental way, the two following tests were designed:

a) Drawing of various angles test.
b) Identification test and inquiry into failures to draw a diamond.

The first test was given to four hundred mentally defective patients tested subsequently on the Revised Stanford-Binet test, whose I.Q's varied from 20 to 80.

The second test was given only to those patients who failed to draw a diamond.

(i) Purpose of experiment.

The direct purpose of these two tests was to supply us with answers to the definite questions embodied in the design of the tests. It was also expected that it would be possible to make some more observations in the course of testing, which, combined with the analysis of results of the two above tests, could indicate whether the line of our investigation is correct.

The drawing of various angles test was a direct outcome of the observations made previously. It was intended to investigate the relationship between the inability to draw a diamond and an obtuse angle, also the relaive difficulty of drawing various angles.

The identification test was designed in order to verify experimentally the commonly held belief that a failure to draw a diamond is determined by some perceptual defect. It was our aim to find out whether this was really the case, and, if so, to what extent perception could be held responsible for failures in the simple drawings. As a supplement to that experiment, in every case when a patient failed to draw a diamond in the routine testing, a simple inquiry was decided upon, which, it was expected, could throw some light on his perceptual processes.

It was hoped in the course of subsequent testing to make some further qualitative observations with regard to performance time and pressure exerted, while drawing, by those patients who failed to draw a diamond. We were also interested whether there is any relationship between the failures in drawing and level of intelligence.

(ii) Description of tests and procedures.

a). Drawing various angles test.

White sheets of paper 4 x 5 inches in size were prepared with three drawings on each; an acute angle, a right angle, and an obtuse angle. They were given to all patients in the subsequent routine testing, asking them to copy on these sheets the already drawn angles. It was anticipated that some patients might draw the required angles with two separate movements, thus escaping, what we thought, the chief difficulty in making the change in direction of moving the hand. To avoid this possibility instructions were given in the following words: "Draw these angles in one movement, like this'- demonstration, "Keep your pencil on the paper while drawing, do not lift your pencil up". When the experimenter feels that the patient has understood fully his instructions then an experiment follows. When it was completed the name, mental and chronological age of the patient was recorded on each sheet.

b) Identification test and inquiry.

On a piece of white cardboard, 5 x 13 inches in size, five figures were drawn in the following order: a rhombus, a triangle, a trapezium, a diamond and a square. On a separate piece of the cardboard a diamond was drawn identical with one printed on the record form of the Revised Stanford-Binet test. When a routine test has been completed, and when none of the three attempts to draw a diamond were successful, then a small piece of cardboard with a diamond drawn on it was presented to the patient and he was asked to have a good look at it. After five seconds this drawing was removed and another big piece of cardboard with five figures drawn on it was shown to the patient, and he was asked to point out the same one as he saw the moment before. If he should point to a wrong figure, then we could legitimately suspect some perceptual defect; if he should point to the correct one, the perception, however defective it may be in mentally defective patients, seems to be not the determining factor of the failure to draw a diamond. In all cases when a patient failed in his three attempts to draw a diamond, he was asked to have a good look at his drawings and at the printed diamond and to say whether they were alike. His responses were recorded on the separate sheet of paper.

(iii) Results of the tests and of the inquiry into failures.

If we arrange drawing results with regard to the correct drawing of an obtuse angle and a diamond, the picture is as follows: 93 per cent of adult patients who were able to draw an obtuse angle were also able to draw a diamond. The remaining 7 per cent were able to draw an obtuse angle, but they were unable to draw a diamond. It should be mentioned that this 7 per cent of subjects while drawing an obtuse angle were very slow on the turning point, it means, they had some difficulty in changing the direction of their hands.

About 6 per cent of subjects who were unable to draw an obtuse angle, were able to draw a diamond, it should be, however, mentioned that they drew a diamond by four separate pencil strokes.

It seems to be quite clear that there is a very high correlation between an ability to draw an obtuse angle and a diamond, as it was already guessed and expressed in our first basic assumption.

This ability to draw a diamond or an obtuse angle is curiously related to the I.Q's of the patients as measured on the Rev. Stanford-Binet Test. All adult subjects below 38 I.Q's were unable to draw any of those figures, all adult patients with I.Q's above 57 were able to draw them both. It is necessary to mention that I.Q's of mentally defective children are as a rule misleading because of their unknown and greatly varied rate and final range of mental development. Because of this, although we have collected data of children's drawings as well, we have not included them in the present calculations.

If we arrange our results with regard to the success of drawing various angles, the picture is as follows: about 50 per cent of tested subjects were able to draw an obtuse angle, about 69 per cent were able to draw an acute angle, and about 80 per cent were able to draw a right angle.

It seems that the drawing of an obtuse angle presents the greatest difficulty and the drawing of a right angle the smallest to the defective subject. An acute angle seems to be in some intermediate position between these two.

The result of the identification test can be summarized as follows: in every case when a patient was able to pass the test designed for the fourth mental year, he was also able to identify a diamond among other figures. So that perceptual error as determining factor of failure to draw a diamond above that level of development seems to be very unlikely.

This is not altogether surprising because one of the sub-tests designed for fourth mental year in the Rev. Stanford-Binet Intelligence Scale contains an identification of simple geometrical figures very similar to our identification test.

The absence of perceptual error so far as simple drawings are concerned appears to be also confirmed by the results of inquiry. When patients, who were unsuccessful in three attempts to draw a diamond, were asked whether their drawings and printed diamond were alike, they never answered "yes". The most common replies to the question: "Are they alike?" were as follows: "I am not a good scholar; I was not much at school; I am not good at drawing; I have not got a ruler; they are difficult to draw; I cannot see very well; I have not got a chance to learn" etc.

These answers show that patients clearly perceive the difference between their drawings and the printed diamond; they also know that they are unable to draw it, and they try somehow to justify their failures. The tendency to justify one's failures is obviously not the exclusive privilege of so called normal individuals.

On the whole, it is possible to draw the following three conclusions from the above described preliminary experiments:

(a) There is a high correlation between the ability to draw a diamond and an obtuse angle.
(b) There are various degrees of difficulty involved in the drawing of an acute, a right, and an obtuse angle.
(c) Perception, so far as simple drawings are concerned, seems to play no significant role.

4. New Observations.

In the course of routine testing and conducting our preliminary experiments, some observations have been made which seem to be relevant to the investigation, and particularly to the concept of skill as it was defined in Chapter One.

There appears to be some relationship between the ability to draw an obtuse angle or a diamond and the scholastic attainments of an individual, especially his writing ability. The majority of patients who cannot draw these figures are also unable to write, and very few of them can read single, separate words. On the other hand, the ability to write was most frequently observed among patients with relatively low testing scores, but who were able to draw an obtuse angle. This relationship between the ability to write and to draw an obtuse angle would not appear to be particularly difficult to explain, even at this early stage of investigation.

The drawing and writing, however simple and undeveloped, are both undoubtedly skilled performances; any essential impairment observed in one of them is bound to affect the other. As some defectives, who cannot draw an obtuse angle, thus show an unability to execute angular changes in the hand direction, it can be expected, that they would also be unable to write, during which it is necessary constantly to vary the hand direction and its pressure. Some of them, however, can print very simple words using separate pencil strokes, employing chiefly straight or curved lines, occasionally changing the direction of the hand in this way as the drawing of a right angle would require.

Another observation, which was made during the routine testing, is very difficult to explain. It has been observed that some patients, irrespective of whether they were able or not to draw a diamond, showed a marked tendency to decrease in size each of their three subsequent attempts to draw a diamond. As the performance is very simple and short in duration, we can hardly suspect that decrease in the size of drawings, determined directly by the decrease in movement, could be due to the onset of fatigue, during which an individual shows an involuntary tendency towards the reduction of his muscular efforts.

The gradual decrease in the size of drawings could probably be explained by the rate of the acquisition of drawing skill. At the beginning of learning of any skilled performance an individual usually executes many unnecessary movements also his essential movements are 'too-large'. As the learning progresses there is an elimination of unnecessary also a reduction of essential movements to the required level. The rate of acquisition of any skill depends, of course, on many factors, but the most important of them seems to be the complexity of the required patterns. If skill is relatively simple, the formation of motor patterns is easy and the rate of skill acquisition is very rapid. In their first attempt to draw a diamond patients somehow formed motor patterns, it does not matter whether they were correct or not, and, in the subsequent drawings they rapidly reduced their movements, not only to the required level, but far below it. There could be, of course, some other explanations, more convincing than the above, of this phenomenon which manifests itself so frequently in the drawings of mental defectives.

It has also been observed that there is frequently a striking similarity, as far as the shape is concerned, between the three subsequent attempts to draw a diamond, it does not matter whether those drawings are correct or not. Although the reduction in the size of drawings is frequently observed, their shape tends to be well preserved. The last observation seems to confirm the generally held belief that mental defectives can modify their responses, motor or otherwise, only to a certain degree. It should be added, however, that they can and do modify some set of patterns as a whole, but they seem to have a considerable difficulty in executing any variation between particular patterns within this set.

And lastly, there seems to be some further qualitative confirmation of our previous assumption, that in the drawings of mental defectives, whether it be angles or diamonds, there is a marked increase in the pressure of the pencil on the drawing paper and also some decrease in drawing performance time.

The results of the preliminary experiments also the above described observations indicate that the present line of investigation of skill seems to be quite promising.

The next logical step in our work appears to be the analysis of drawing failures which may throw some light on the motor mechanism involved, the quantitative measurements of the hand pressure and drawing performance time and finally investigation of the relationship between various elements of drawing skill. It should be possible to relate the ability or inability in drawings to the intelligence level as it is measured by verbal or practical tests.

CHAPTER III.

ANALYSIS OF DRAWING FAILURES.

Although it was possible to draw some conclusions from the results of the preliminary experiments, the vital question remains, namely: why young children and some mental defectives cannot change the direction of their moving hand as is required when the drawing of certain angles or simple geometrical figures is in progress.

In order to deal with this particular problem the analysis of drawing failures was attempted.

1. Selection of drawing failures.

It seemed to be unnecessary to extend our analysis to all the drawings obtained from the preliminary experiments, i.e. performed by mentally defective patients within the range of 20 and 80 I.Q.'s on the Revised Stanford-Binet test.

As all patients with I.Q's above 57 were able to draw obtuse, acute and right angles and also a diamond, there was no need to consider their drawings because of the absence of drawing failures in that group.

All patients with I.Q's below 38 were unable to draw an obtuse angle; some of them could draw a right angle, and only very few an acute angle. Because of so many drawing failures present in that group, some of them probably determined not so much by motor disability as by an inability to grasp and remember instructions given, the results of that group were also excluded from further considerations.

Our investigation of drawing failures shall, therefore, be confined to the group of adult mental defective patients whose I.Q's are between 38 and 57, where the results of drawings seem to be unpredictable beforehand.

A selection of drawings given in Figures 1, 2, and 3 shows the most common drawing responses to the various presented angles and can be considered as representative samples of that particular group.

3. Unsuccessful drawing responses to the acute angle.

The variety of unsuccessful drawings performed by the patients when an acute angle was presented to them is illustrated in Figure 1.

It seems to be possible to divide all these drawings into the following groups:

(i) 'Rounded up' drawings.

In drawings 1 and 2 both lines which constitute arms of an acute angle are curved; in drawings 3, 4, 9 and 10, only one line is visibly rounded.

(ii) An attempt to draw a right angle.

Drawings 5 and 6 are typical examples where patients attempted at first to draw a right angle and they added one more line in order to keep their drawings in some shape roughly resembling an acute angle.

Drawings 7 and 8, because of their unconventional position, seem to be more like a right than an acute angle

(iii) Disconnected or crossed lines.

In drawings 9, 10, 11 and 12 an acute angle was drawn by two separate pencil strokes in spite of instruction: "Keep your pencil on the paper while drawing, do not lift your pencil up"

In the drawing 9 and 10 lines are disconnected, in 11 and 12 they are crossed.

(iv) Unclassified drawings.

Drawings 13, 14 and 15, although relatively rare,

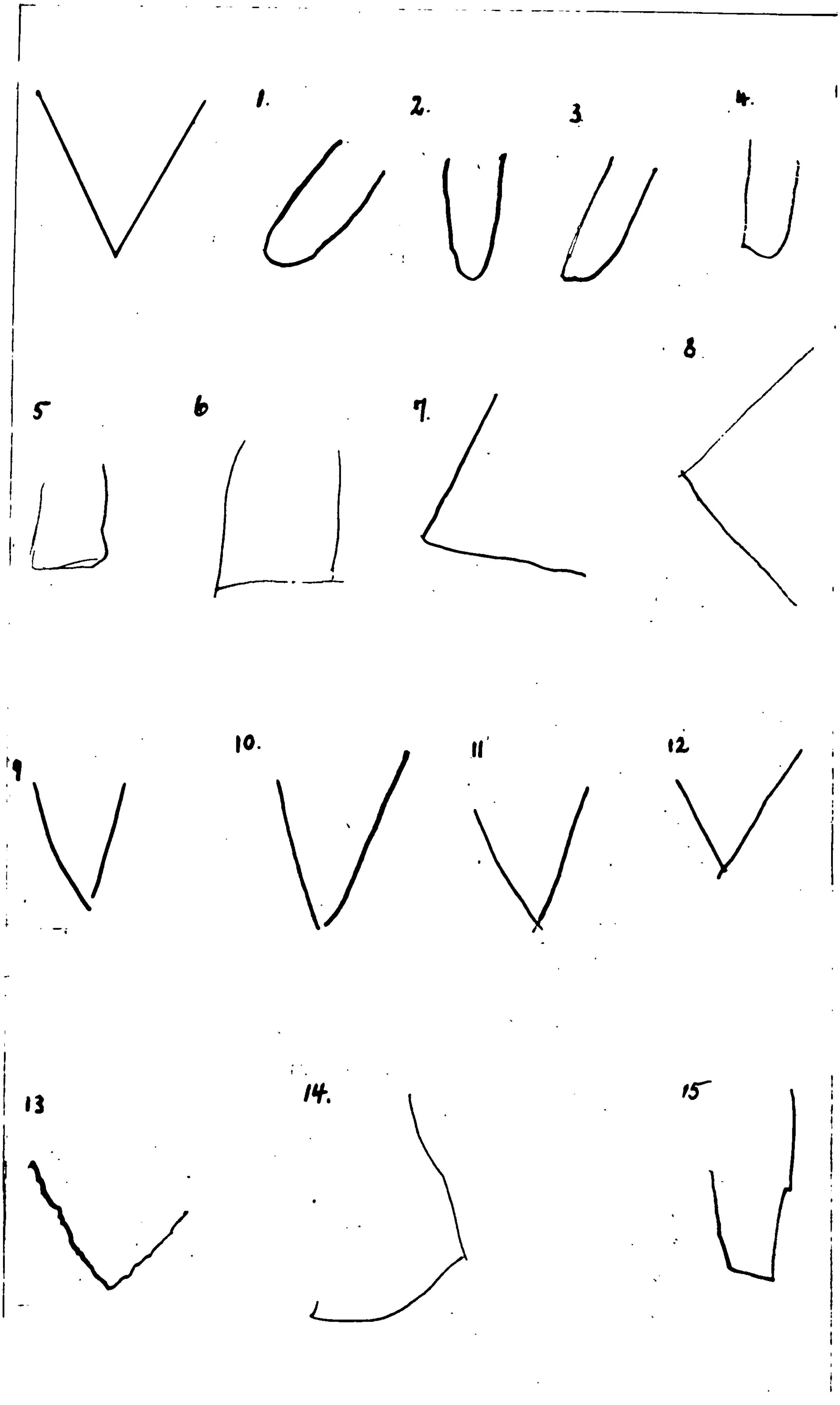

Figure 1. Drawing responses of fifteen mentally defective subjects when asked to copy an acute angle.

3/corrects/2

can illustrate the difficulty not only of drawing an acute angle, but also the difficutly of drawing the arms of the angle as straight lines.

3. Unsuccessful drawing responses to the right angle.

Unsuccessful drawings as a response to a right angle are presented in Figure 2. Very similar grouping of drawings, although not identical with the previously described, was attempted here.

(i) 'Rounding up'

The drawing 1, 2, 3 and 4 can be taken as an illustration of the rounding up tendency.

(ii) Drawing of an acute angle.

Drawings 4, 5, 6 and 7 seem to be somehow unusual because they appear to show that these patients preferred to draw an acute angle which is more difficult, instead of a right angle which is more easy to perform, and which was actually presented to them. One glance, however, at their previous drawings can dispel this apparent fallacy. All these four patients were successful in drawing previously an acute angle. When a right angle was presented to them they just repeated their last drawing, i.e. an acute angle. There is a striking similarity between the original and the subsequent drawing. The perseverance of lastly formed patterns is very common in mental defectives and it can be observed in various tests. It may mean not only an inability to form a new, more difficult, motor patterns, but it may also mean an inability to vary them, even from difficult to the easy ones.

(iii) Disconnected and crossed lines.

Drawings 9, 10, 11 and 12 show again very similar trends to those in the previous table; that is the

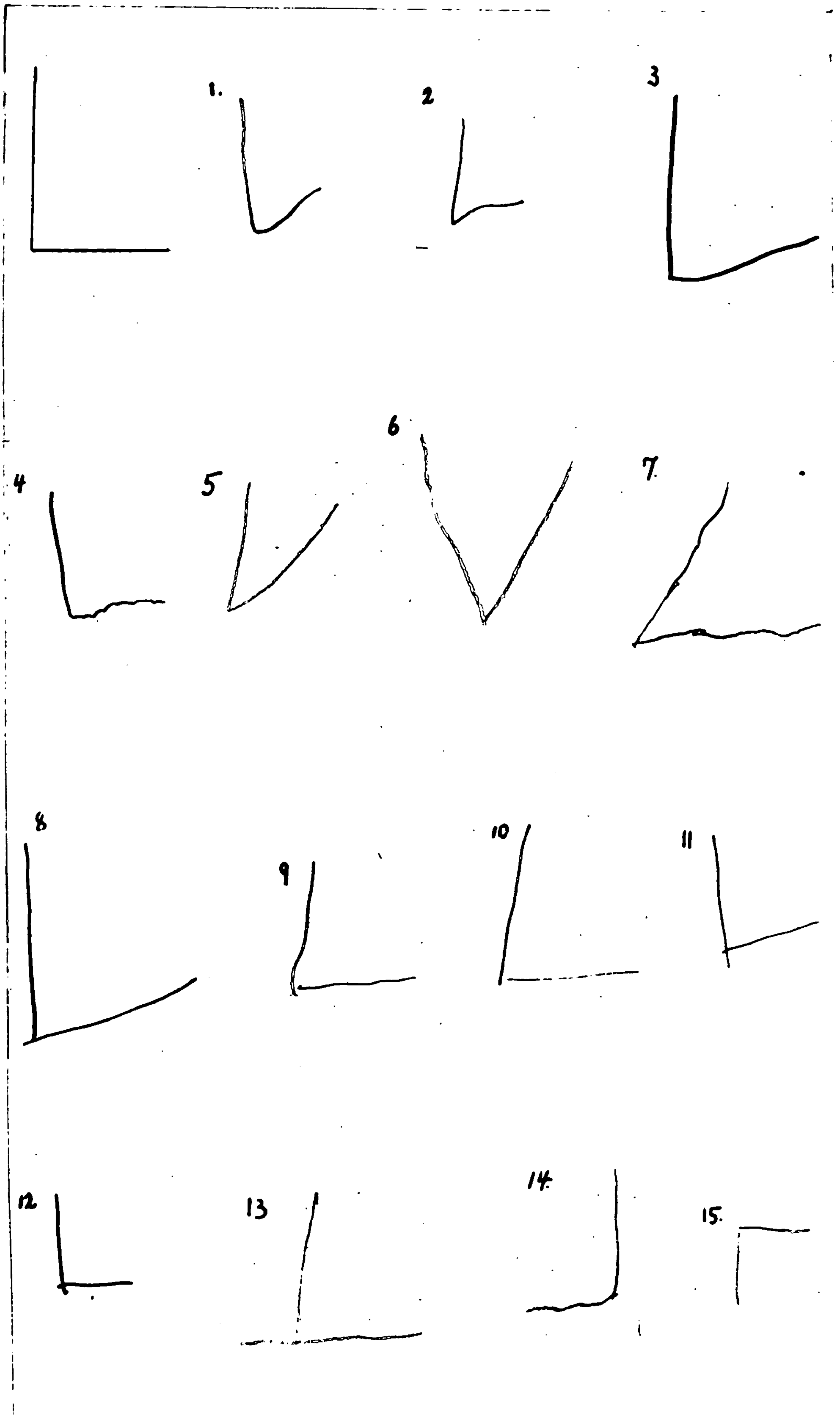

Figure 2. Drawing responses of fifteen mentally defective subjects when asked to copy a right angle.

drawing an an angle by using the two disconnected lines.

(iv) Unclassified drawings.

Drawings 13, 14 and 15 are rather uncommon, particularly 14 and 15, where the drawings are reversed. This tendency to reverse drawings or even letters occurs quite often in some hemiplegic patients, but it may, however, infrequently occur in non hemiplegic and in very young children.

Although the causes determining this particular phenomenón are not clear, it seems to be determined by the temporary or permanent injury to the pyramidal system somewhere in the internal capsule, cerebral peduncle pons or upper part of the medülla oblongata.

4. Unsuccessful drawing responses to the obtuse angle.

The unsuccessful drawing responses to an obtuse angle are illustrated in Figure 3. The drawing of that particular angle presents the greatest difficulty to patients, and probably because of that, there is the largest variety of responses obtained.

(i) 'Rounding up'

The drawings 1, 2, 3 and 4 although somehow different as far as their shapes are concerned, nevertheless, show clearly this particular 'rounding up'.

(ii) Drawing of right and acute angles.

Although the drawings 5 and 6 primarily are unsuccessful attempts to draw a right angle instead of an obtuse angle, they also show some degree of 'rounding up!

The drawings 7 and 8 are much more successful attempts to draw a right angle, although their position differs somehow from a customary way of drawing of a right angle.

The drawings 9 and 10 are successful attempts to draw an acute angle when an obtuse angle has been presented to the patients.

On the whole all these drawings, from 5 to 10, show that when patients are faced with drawing which is too difficult for them to perform, they tend to make a drawing involving less difficulty and which roughly resembles the presented drawing.

(iii) Disconnected and crossed lines.

Drawings 11, 12, 13 and 14 are illustrating that those patients perceived correctly the presented figure and they followed its shape in their drawings. Because of their inability to perform that particular angular movement as it was required, when an obtuse angle is drawn according to instructions given, they tried to go around that difficulty by making drawings in two separate pencil strokes.

(iv) Drawings illustrating difficulty to draw an obtuse angle

Drawing 15. That patient drew a straight line instead of an obtuse angle. He did not attempt to change direction of his pencil.

Drawing 16. Here is a definite, however unsuccessful, attempt to change direction of moving pencil. Because this bid failed, the patient continued to draw almost a straight line further down.

Drawings 17 and 18. These two patients tried to solve the problem of drawing of an obtuse angle in an almost identical way. They both attempted unsuccessfully to change direction of their pencils, and they both drew subsequently right angles.

Drawing 19. Here is an attempt to change direction resulted in drawing of a right angle. That patient, however, realized that he moved his pencil to the opposite direction, he probably also realized that the angle drawn

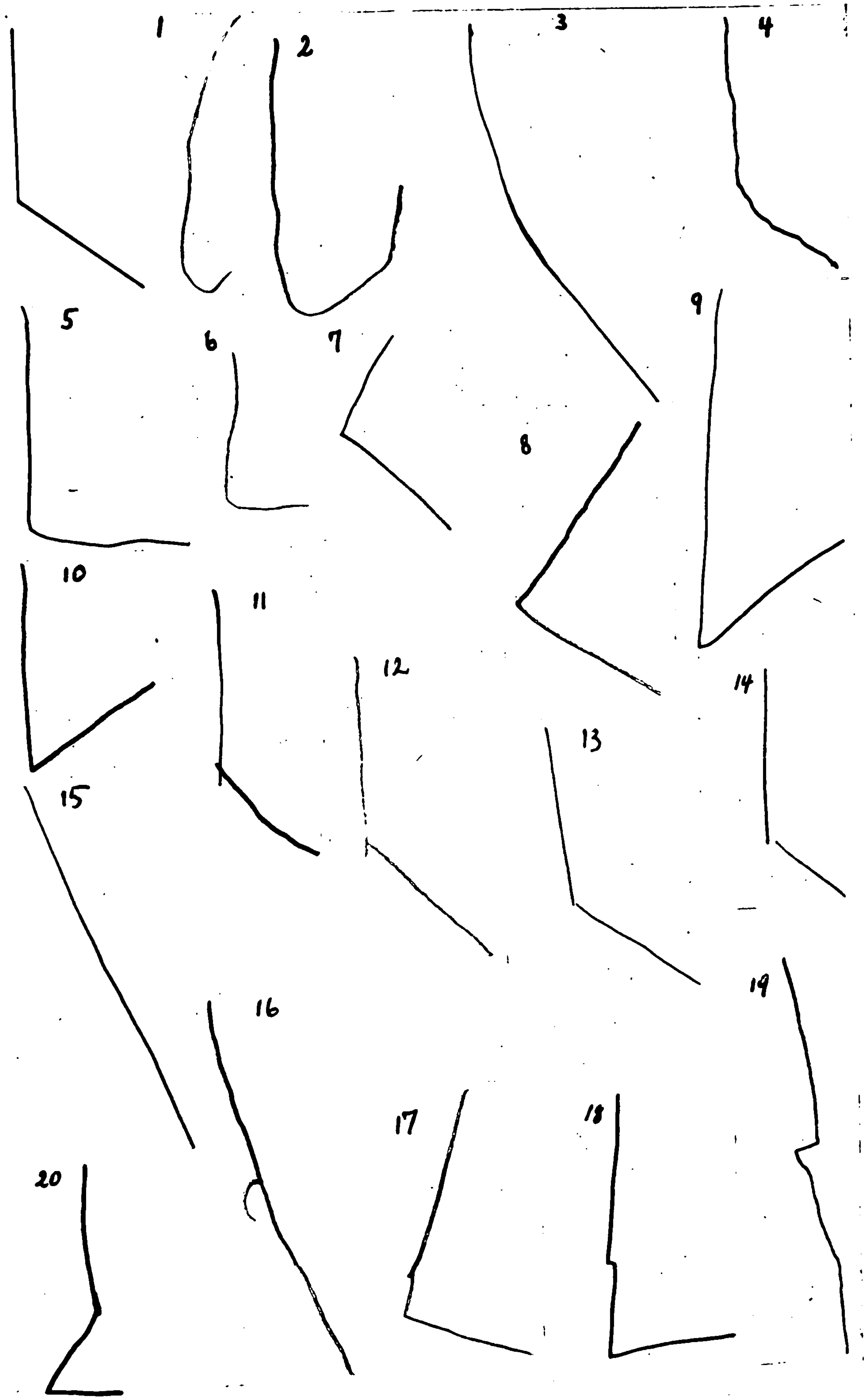

Figure 3. Drawing responses of twenty mentally defective subjects when asked to copy an obtuse angle.

by him was different from the required one, and he continued to draw a line down without any further attempt to change the direction of his pencil.

Drawing 20. The patient drew a straight line at first, then he stopped for a while, and then moved to the opposite direction, stopped again and finally drew an acute angle. His drawing contains two angles; the first one is an obtuse angle drawn to the left instead of to the right, and then an acute angle.

5. Discussion of drawing failures.

On the basis of the foregoing description of drawing failures some generalization can be attempted.

In all three groups of drawings, illustrated in Figures 1, 2 and 3, which are unsuccessful attempts of mentally defective patients to draw acute, right and obtuse angles, some common trends can be isolated such as 'rounding up' tendency, drawing of some simpler figure when that presented was too difficult and the frequent use of the two separate pencil strokes instead of turning the pencil in the required direction.

All these trends can be grouped under one heading of regressive behaviour and partly explained by the concept of various levels of motor development.

(a) Levels of an early motor development.

According to the requirements of the Rev. Stanford-Binet test, a circle should be performed by an average three year old child, the drawing of a square by a five year old, and the drawing of a diamond by a child of seven.

The observations of psychometricians derived from testing results seem to confirm that the progressive ability of a child follows closely test requirements.

It seems to be possible to mention here our own experiments and observations which suggest that an ability to draw a triangle is developed in the average child when he is about six years old; in the case of defectives, this ability is developed when they are close to the sixth mental year. The drawing ability, whether in a normal child or mentally defective, is undoubtedly determined by his motor development.

If we put forward the concept that there exist various levels of motor development as they are manifested by the progressive ability to draw at first a circle, then a square and finally a diamond, then drawing failures could be explained as due to the arrested or incomplete motor development at some particular level.

The rate of motor development between the two subsequent levels is approximately two years in the case of a normal child; this means that it will take two years for a child of three who can draw a circle before he would be able to form the new motor patterns necessary for the drawing of a square. It seems to be impossible to venture any generalization with regard to the rate of motor development of mental defectives, as it may greatly vary in individual cases, but it could safely be said that their motor development is much slower than that of normal children.

In the attempt to explain drawing failures it is suggested that they are due to the arrested or incomplete development on some particular level. It seems that the expression of 'incomplete' needs some elucidation. If a patient drew an acute angle in response to the presented obtuse angle, we may say that his motor development was arrested on the level of an acute angle, i.e. somewhere about his sixth mental year. It may, however, happen and it did happen many times that some patients, who were able to draw acute and right angles previously, when presented with an obtuse angle made drawings with curved lines; in such cases we may say that their motor development, although not quite arrested, was nevertheless somehow incomplete on the level of right and acute angles.

It may be held against us that in our analysis of failures we were concentrating chiefly on the drawings of various angles and not on the drawing of geometrical figures such as a circle, a square and a diamond as used in the Revised Stanford-Binet test, and, therefore, our subsequent conclusions could only be applicable to the drawing of angles. This is, however, not the case, It was proved experimentally, that the abilities to draw a diamond and an obtuse angle, if not identical, are highly correlated. There is also abundant evidence suggesting that the same is true with regard to any simple figure, i.e. an ability to draw a right angle is correlated with an ability to draw a square, an acute angle with a triangle and a curved line with a circle. We are justified in expressing these relations in the following generalization: The ability to draw a simple geometrical figure is determined by the ability to draw an essential element of it; and our conclusions are valid not only to angles but to figures as well.

There seems to be no difference, as far as motor mechanism is concerned, between the drawing of a square and a right angle, and there is no experimental evidence suggesting the defect in perception at that level of development. The results of preliminary experiment in drawing of various angles, carried on the group of 400 mental defectives, show that 80 per cent of them can draw a right angle, 69 per cent can draw an acute angle and only 50 per cent can draw an obtuse angle. The same proportion of successful drawing was maintained in the group of defectives with I.Q's between 39 and 57.

It may be concluded that 20 per cent of patients taking part in the experiment have been arrested in their motor development at the level of a square or a right angle, 31 per cent at the level of a triangle, and 50 per cent at the level of a diamond.

(b) Regressive Behaviour.

By regression is meant an inability to form the appropriate patterns and the use of easier, previously established, patterns.

If a child is presented with a drawing which is too difficult for him, it means that it is beyond his present motor development, most likely he would try to draw it by employing the motor patterns already established, in other words he would exhibit regressive behaviour. This happened exactly with mental defective patients, whose whole development, motor including, had been arrested at a certain level. The 'rounding up' tendency and the drawing of a simpler figure when the presented is too difficult to perform seems to point directly to the employment of patterns which have been already established at the lower level of development. Drawing a figure by the use of two separate pencil strokes, whether those lines would be disjoined or crossed, seems to be some variations of, essentially the same, regressive behaviour.

There is, however, another problem which should be considered at this stage, i.e. the range of regression. A patient, who is able to draw right and acute angles, when presented with an obtuse angle which is beyond his motor development, may draw an acute or right angle; he may also draw some unidentified geometrical drawing where curved lines or 'rounding up' are predominantly employed. In short, his range of regression may vary. In the case of a patient drawing an acute angle in response to an obtuse angle, he seems to regress only one step back to the nearest level of motor development; when he draws a right angle he would regress two steps back, and when he is drawing some figure with curved lines, his regression seems to be three steps back on the scale of motor development. The range of regression may be influenced in some cases by the drawing immediately preceding the task which presents some difficulty, but on the whole, it seems to be chiefly determined by the degree of perfection of previously established patterns. If faced with too difficult a task the patient tends to regress and to use the patterns which have been most perfectly already established. He may 'jump over' the intermediate levels at which motor patterns, although present, are only poorly developed. The study of drawings performed by mental defectives seems to justify the above given explanations.

It seems possible to venture the following general statement, that the range of regression of an individual is probably the best index of his incomplete development, whether it would be motor or any other, at same particular level.

(c) Drawing Movements.

We have attempted up to now to explain the inability to draw some angles which occurs in mental defectives and young children by postulating the concept of inadequate motor development and its various levels.

Although it is possible to explain drawing failures to a certain extent by the acceptance of this concept, it adds, nevertheless, very little to the understanding of the motor mechanism involved in the performance of angular changes in the hand direction.

It seems to be possible to throw some light on this mechanism by discussing in detail hand movements which are executed while the drawing of some simple geometrical figures or angles is in progress.

It should be, however, mentioned here that this discussion, although based on observations and evidence obtained from drawing experiments, is bound to be chiefly speculative, as the exact data with regard to muscular activity involved in drawing are complex and cannot yet be ascertained even by the use of electro-myographic devices.

Let us begin our discussion with the analysis of a circle or a curved line which is an essential element of it. These can be performed by a normal child of three years of age. The group of muscles involved in the execution of a circle or a curved line seem to be predominantly of flexor type. As flexors are the dominant group of muscle in childhood, any movement executed by them is made possible even at that early stage of motor development. The dominance of flexors not only facilitate the formation of these particular motor patterns but it may be also held as responsible for their persistence which may hamper the next stage of motor development. It was observed many times during the drawing experiments, that some mental defectives, when presented with an obtuse angle 'jump over' incompletely developed motor patterns at the level of right and acute angle and regressed to the firmly established patterns at the level of a circle.

A drawing of a square or a right angle can be performed by a normal child of five years of age. The vertical line which constitutes the first arm of a right angle is executed by the employment of flexors, particularly by flexion of a thumb, an index and a middle finger. The horizontal line which constitutes another arm of a right angle seems to be executed by the extension of fore-arm muscles, while muscles of the wrist are firmly fixed acting as synergetists.

As it was said before, any angular change in direction of the hand is determined by the interaction between flexors and extensors. A change in direction as is required when a right angle is drawn, is relatively easy, because of the difference in the extent of muscle group involved. The extensors of the fore-arm are a much more powerful group than the flexors of the three fingers, and because of that, the dominance of flexors is neutralized and could not affect significantly the angular change in direction of the moving hand. The difficulty involved in the drawing of a right angle is relatively small as 80 per cent of patients with I.Q's between 38 - 57 were successful in this particular drawing. Failure to draw that angle seems to be due to the inability to inhibit instantly the flexion of the thumb, index and middle finger when the vertical line is completed; if this activity of flexors overlap the subsequent action of the fore-arm extensors, we shall get a drawing with a curve in place of a right angle. Any attempt to counteract this prelonged flexion by the increase of extension will result in drawing of a wavy line which constitutes the secnnd, horizontal arm of a right angle.

The ability to draw an acute angle or a triangle appears to be developed in a normal child when he is somewhere between his fifth and seventh years. The ability is manifested in mental defectives when they are between their fifth and seventh mental years.

The first line down which constitutes the first arm of an acute angle is executed by flexion of a thumb, index and middle finger. There is also some flexion, however very small, of the wrist. The second line upwards, which constitutes the other arm of an acute angle, seems to be executed by the extension of all muscles engaged previously in the flexion. This picture seems to be true when an acute angle is drawn correctly, but in the case of defectives and young children before they reach that particular level of motor development, there are some modifications of drawing performance. The action of flexors which should cease when the first arm is completed, is still in operation, however decreased, when the extensors play their part. This action is somehow extended in time, overlapping the action of extensors. As the final result of the dominance of flexors we can observe drawings with their arms distinctly 'rounded up' or curved due to this additional and unnecessary force exerted by the flexors. If we observe carefully an unsuccessful attempt to draw an acute angle and particularly its second arm, we can see quite clearly how the dominance of flexors manifests itself at the two points of the drawing. The first one is 'rounding up' the angle itself, due to inability to inhibit the action of flexors when the first arm was completed, the second one is the curving of the upper end of the second arm, due probably to inability to inhibit for a sufficient length of time the flexor activity.

The middle part of the second arm is relatively straight, due probably to temporary inhibition of flexors by the central nervous system, to mechanical counteraction of extensors, which is, however, inadequate to control movement at every point during drawing performance.

The drawing of an obtuse angle seems to offer a considerable difficulty for defectives and young children and it is also the most difficult to analyse. The vertical line, constituting the first arm of an obtuse angle is executed in the usual manner, i.e. by the flexion of a thumb, index and middle finger. The second line down and slightly to the right, seems to be executed by the further increased flexion of a thumb, the diminished flexion of an index and the middle finger and by the extension of wrist and also probably by some extension of fore-arm muscles.

Let us consider some of the drawings illustrated by Figure 3. When a patient is unable at the turning point to decrease sufficiently flexion of an index and middle finger, and to increase at the same time flexion of a thumb, wrist and the fore-arm extensors, then he is drawing a line curved gradually as illustrated by the drawing three, Figure 3.

When flexion of thumb, wrist and fore-arm extensors is sufficient at the turning point, but the flexion of an index and the middle finger decreased too much, then a patient is drawing almost correctly a right angle (drawing 5, Figure 3).

When flexion of the thumb, wrist and fore-arm extensors is correct at the turning point, but if the flexion of an index and the middle finger decreases to zero, then a patient is drawing an acute angle. (Drawings 9 and 10, Figure 3.)

The three above given examples show that the motor patterns required when drawing an obtuse angle, have been distorted by the insufficient or complete lack of muscular action of the index and middle fingers at the turning point. When a patient inhibits at the turning point flexion of an index and middle fingers, and flexion of a thumb to a certain extent, employing at the same time flexion of the wrist and fore-arm muscles, then he will turn his pencil to the left instead of to the right, drawing thus a right angle in the wrong direction (Drawing 16, Figure 3).

When flexion of a thumb is inhibited, but flexion of an index and middle fingers are in operation with flexion of the wrist and the fore-arm muscles at the same time, then we shall obtain the figure illustrated by drawing 20, Figure 3.

It is possible to say that the formation of motor patterns required when drawing an obtuse angle become very complex, especially at the turning point; there is a considerable modification of the operating patterns, i.e. the decrease in one part of them and an increase at the same time in another part. There is also formation of new patterns and integration of all distinct patterns into one single whole. It seems to be true to say that failures to draw an obtuse angle are due to the inability of an individual to form and operate these complex motor patterns. Only 50 per cent of mental defective patients were able to draw an obtuse angle correctly.

(d) Drawing failures and skill.

Let us now consider how drawing failures are related to skill as it is defined in the first chapter of this work.

As we did not attempt to measure the pressure exerted during the drawings and their performance times, we can discuss at present only one particular aspect of skill, i.e. the maintenance and change of direction of the moving hand.

The drawings given in Figures 1, 2 and 3 illustrate that some of the mental defectives, whose I.Q's are between 38 - 57, are unable to change direction of the hand as required when drawing an acute, right and obtuse angle. These drawings also show that the most common level of regression, it does not matter which particular angle is attempted, is to the level of curved lines.

There is another striking feature of these drawings: in the majority of cases when the pencil has not been lifted up while drawing, lines constituting arms of an angle are curved.

The preference to employ curved lines by patients and their ability to draw straight lines seems to be closely related to the previously referred concept, i.e. dominance of flexors. The drawing of a circle or a curved line which is an integral part of it, is made possible because these movements are determined chiefly by the action of flexors; the drawing of a straight line seems to be due to the harmonious interaction between flexors and extensors. As many mental defectives are permanently arrested at the earlier level of motor development where flexors are dominant, they can execute quite well movements effected by them, but they have difficulty in angular changes of direction or the drawing of a straight line, as these are determined by the interaction between flexors and extensors, which is in turn impaired because of the dominance of flexors over extensors.

It should be mentioned, however, that there seems to be a considerable difference between the drawing of separate straight line and the drawing of a straight line immediately following the change in direction of the moving hand. In the majority of cases where a patient drew an angle in the two separate pencil strokes, lines drawn that way are relatively straight, they tend to be curved if they proceed or follow immediately the change of direction. It seems that the dominance of flexors is more difficult to control when a movement is complicated by the angular change in direction as in the drawing of an acute angle or a right angle without lifting up the pencil. In such cases flexors cannot be inhibited sufficiently before the change in direction is taking place or immediately after the turn of the pencil. Their action seems to be somehow extended in time.

The development of motor patterns responsible for angular changes in the hand direction seems to be relatively easy if this change is effected by the interaction between weak group of flexors and powerful group of extensors.

It is more difficult if the angular change, however simple, is due to the interaction between flexors and extensors which are of almost the same volume. The difficulty seems to increase further, if the operating motor patterns have to be modified in the course of movement and new patterns have to be added and integrated into one whole with the already existing modified patterns, as is necessary when an obtuse angle is drawn. Ability to modify motor patterns in the course of their operation and to introduce new patterns seems to be basic and absolutely necessary for the development of any skill.

Although in the course of this work we have been fully aware that for the formation of any motor pattern, skill included, is chiefly respbnsible the cortex and particularly its precentral part, nevertheless, we feel justified in studying and comparing those motor patterns as they are manifested in simple movements, and particularly in angular changes of the hand direction.

CHAPTER IV.

SIMPLE REACTION TIME EXPERIMENT.

The introduction of the Simple Reaction Time test was considered as the necessary, selecting step preceding the main experiment.

1. Reasons for instruction of S.R.T. test.

The results of the preliminary drawing test showed that all adult patients with I.Q's below 38 were unable to draw an obtuse angle and all patients with I.Q's above 57 were able to do this. The next logical step, therefore, was to confine our investigation to those mental defectives whose I.Q.'s lay between 38 and 57. According to their drawing results those patients can be divided into two distinct groups: the first one containing subjects who were unable to draw an obtuse angle and the second one made up of subjects who were able to do this. As we have already analysed the drawing failures occuring in the first group, the next question was, whether we should proceed with an investigation of the pressure exerted by the hand and the drawing performance time in these two distinct groups, or whether some further, selective experiment should be carried out before commencing the main experiment.

It was decided, after some reflection, to introduce at that stage the Simple Reaction Time or in short S.R.T. The reason for the application of this test to our experimental group, i.e. to the patients with I.Q.'s between 38 and 57, are as follows: there is a common belief that the reaction of epileptics, post-encephalitics and other patients, deteriorated for any reason, are much slower than the reactions of other, unaffected defectives; the same seems to be true of patients with some specific physical disability like athetosis, hemiplegia, etc.

If these beliefs could be experimentally substantiated then our present experimental group has to be selected again in order to eliminate all those patients from further experiments whose delayed reactions are due to some specific causes. As our next main experiment was designed to measure hand pressure, performance time and the relationship between these items, it was thought absolutely necessary to eliminate from further investigation all those patients with delayed reactions due to some specific causes as they might be subsequently handicapped in the performance time experiment. Although it is open to discussion and experiment whether, and by how much the S.R.T. of an individual is related to his performance time. It seems reasonable to expect some relationship between these two items in mental defectives, especially when performance is simple and the level of skill developed is very low.

2. Purpose of the S.R.T. experiment.

The chief purpose of this experiment was to measure the S.R.T. of all adult patients who took a part in the previous preliminary experiments and whose I.Q.'s lay between 38 and 57. As we had already divided all these patients, according to their drawing ability, into two distinct groups: the first group composed of those who were unable to draw an obtuse angle, and the second one made up of patients who were able to do this; we expected to compare both these groups according to their S.R.T. results and to see whether they differed significantly. In both these groups were epileptics, post-encephalitics, hemiplegics, patients suffering from athetosis or patients deteriorated because of some unspecified reasons. If the S.R.T. of these patients, belonging to various clinical groups, should be slower than the mean of that group to which they belonged according to their drawing ability, then we would eliminate them from our two experimental groups and from further investigations. It was also decided to carry on the same experiment, under identical conditions, on the third group of seventy subjects, composed of nursing staff, in order to make comparative evaluation of the results obtained.

3. Instruments and procedure.

To measure visual reaction times the chronotron 25B was used. This instrument gave a direct reading of time intervals in milliseconds. The chronotron, the source of light and two Morse Keys were connected in circuit. When the experimenter pressed his key he set the chronotron and the source of light in action. When a patient pressed his key the circuit was broken and it was possible to read the S.R.T. from the dial on the chronotron. The pilot experiment was carried out to make the necessary adjustments and it was found that the experimenter's key had to be replaced by a noiseless one as some subjects reacted to the sound of the closing key rather than to the light. A hand rest for the subject was provided. The experiment was conducted in a semi-dark room. A black screen was put between the chronotron and the source of light which was placed 12 inches above the table at which the subject sat. The usual distance between the lamp and the eyes of the subject was 36 inches, but some subjects asked to have light nearer and then the lamp was moved according to their wishes. When the subject was seated comfortably at the table with his hand on the hand-rest and his index finger on the button of the Morse Key, he was told: "When this light is on, press your button immediately; try to be as quick as you can". After a demonstration he was given at least seven trial runs and then twenty readings were taken from which the average S.R.T. was calculated. In a few cases it was necessary to give more than seven trial runs.

4. Arrangement of groups and results.

The simple Reaction Time experiment was carried out on 239 adult subjects, 169 of these were mental defectives, whose I.Q.'s varied between 38 and 57 and who were selected by the writer according to their results obtained in the drawing experiment, the remaining 70 subjects belonged to the nursing staff. The group of defectives was composed of 93 males and 76 females; in the group made up of nursing staff there were 35 males and 35 females, they were selected by the Chief Male Nurse and the Matron respectively.

The results of the S.R.T. experiment obtained with the defective patients were arranged into the following groups:

(a) Hemiplegic patients:- 3 female subjects.

(b) Deteriorated patients:- 6 subjects,
4 male and 2 females.

(c) Post-encephalitic patients:- 5 subjects,
3 males and 2 females.

(d) Epileptic patients:- 35 subjects,
25 males and 10 females.

(e) Clinically unidentified patients (Exclusive of the above groups)
120 subjects;- 60 males and 60 females.

The results of the S.R.T. obtained with each of these five groups are arranged below into two columns: the first column contains subjects who were able to draw an obtuse angle and the second subjects who were unable to do this. Together with the results of S.R.T. in the group of epileptics there are given two other items: drugs and epileptic fits; the presence or absence of each or both of these factors seems to be related to the result of the S.R.T. of each individual subject.

(f) Nursing Staff:-

This group is composed of 70 subjects, 35 of them are male and 35 are female nurses.

A/ The results of the S.R.T. of Hemiplegic patients.

S.R.T. is given in milliseconds.

(i) Subjects who cannot draw an obtuse angle.

No of subject	S.R.T.
1	481
Mean	481

(ii) Subjects who can draw an obtuse angle.

No of subject	S.R.T.
1	176
2	308
Mean	242

The mean for both hemiplegic groups: 321.6

B/ The results of the S.R.T. of deteriorated patients.

(i) Subjects who cannot draw an obtuse angle.

No of subject	S.R.T.
1	932
2	1020
3	952
4	594
Mean	874.5

(ii) Subjects who can draw an obtuse angle.

No of subject	S.R.T.
1	1305
2	1100
Mean	1202.5

The mean for both deteriorated groups: 1038.5

C/ The results of the S.R.T. of Post-encephalitic patients.

(i) Subjects who cannot draw an obtuse angle.

No of subject	S.R.T.
1	375
2	385
Mean	380

(ii) Subjects who can draw an obtuse angle.

No of subject	S.R.T.
1	274
2	290
3	209
Mean	257.6

The mean for both post-encephalitic groups: 313.8

D/ The results of the S.R.T. of epileptic patients.

S.R.T. is given in milliseconds.

(i) Subjects who cannot draw an obtuse angle.

No. of subj.	Fits.*	Drugs*	S.R.T.
1	x	x	553
2	-	-	282
3	-	x	380
4	-	x	362
5	x	x	483
6	x	x	609
7	-	-	932
8	x	x	461
9	x	x	447
10	-	-	478
11	-	-	644
12	x	x	358
13	x	x	694
14	x	x	588
		Mean	520

* Fits and drugs.

1. - denotes the absence of fits or specific drugs for treatment of epilepsy in the last 12 months.

2. x denotes the occurence of fits or use of specific drugs for treatment of epilepsy.

(ii) Subjects who can draw an obtuse angle.

No of subj.	Fits	Drugs	S.R.T.
1	-	-	169
2	-	-	320
3	-	-	252
4	x	x	307
5	-	x	288
6	-	x	290
7	x	x	530
8	-	x	378
9	-	x	213
10	-	x	354
11	-	x	474
12	-	-	190
13	x	x	387
14	x	x	255
15	x	x	358
16	x	x	441
17	-	x	181
18	x	x	171
19	x	x	275
20	-	-	173
21	-	x	199
		8 Mean	295.5

The mean for both groups: 407.7

E/ The results of the S.R.T. of the undifferentiated mentally defective group.

S.R.T. is given in milliseconds.

(i) Subjects who cannot draw an obtuse angle

(continuation)

No of subject	S.R.T.
1	407
2	366
3	952
4	283
5	301
6	399
7	303
8	250
9	537
10	271
11	299
12	362
13	372
14	302
15	474
16	291
17	563
18	342
19	359
20	394
21	515
22	327
23	452
24	307
25	491
26	333
27	347
28	711
29	594
30	609

No of subject	S.R.T.
31	387
32	628
33	642
34	518
35	452
36	316
37	682
38	342
39	300
40	546
41	297
42	412
43	273
44	520
45	567
46	486
47	383
48	392
49	312
50	323
51	316
52	517
53	364
54	358
55	666
56	575
57	459
58	512
59	367
60	365
Mean	429.9

(ii) Subjects who can draw an obtuse angle.

S.R.T. is given in milliseconds.

No of subject	S.R.T.
1	195
2	259
3	250
4	231
5	232
6	199
7	240
8	293
9	172
10	238
11	252
12	214
13	194
14	272
15	214
16	276
17	279
18	288
19	254
20	226
21	250
22	331
23	230
24	311
25	307
26	237
27	304
28	169
29	309
30	207

/continuation/

No of subject	S.R.T.
31	257
32	293
33	258
34	290
35	225
36	191
37	205
38	274
39	192
40	354
41	178
42	209
43	174
44	266
45	235
46	286
47	210
48	272
49	194
50	165
51	241
52	265
53	182
54	213
55	213
56	289
57	278
58	176
59	295
60	228
Mean	242.5

The mean for both undifferentiated groups: 336.2

F/ The results of the S.R.T. of the group of Nursing Staff.

S.R.T. is given in milliseconds.

No of subject	S.R.T.
1	147
2	182
3	197
4	212
5	167
6	180
7	171
8	144
9	184
10	142
11	159
12	191
13	169
14	177
15	178
16	167
17	197
18	180
19	149
20	163
21	165
22	181
23	218
24	254
25	172
26	184
27	160
28	170
29	167
30	156
31	164
32	182
33	134
34	155
35	232

(continuation)

No of subject	S.R.T.
36	188
37	190
38	214
39	210
40	195
41	218
42	165
43	192
44	215
45	171
46	203
47	154
48	183
49	189
50	176
51	217
52	184
53	190
54	198
55	249
56	200
57	168
58	203
59	224
60	156
61	183
62	128
63	181
64	181
65	204
66	175
67	149
68	199
69	175
70	165
Mean	181.8

5. Discussion of the results of the S.R.T.

The results of the S.R.T. experiment obtained with various groups of mental defectives and with the group of staff can be summarized in the following table:

Group	Nr. of sub-jects	Mean of S.R.T. subj.who cannot draw ob-tuse ang.	Mean of S.R.T. subj.who can draw obtuse angle.	Mean of S.R.T. for both groups.
Hemiplegics	3	481	242	321
Deteriorated patients	6	874.5	1202.5	1038.5
Post-encepha-litics	5	380	257.6	313.8
Epileptics	35	520	295.5	407
Undifferentia-ted group	120	429.9	242.5	336
Staff	70	-	181.8	-

Although it is not possible to draw fully valid conclusions from the results of the first three groups in the above table as these groups are numerically very small, some tentative suggestions could be made.

It seems that hemiplegic patients are not significantly different from the undifferentiated group as far as their S.R.T. is concerned. The only reason for the exclusion of that group from further investigation is our feeling that they could be somehow handicapped in the subsequent experiment whose performance time and pressure of the hand are measured. Although only one hand is actually employed in those experiments, the other seems to have some, let us say synergetic, facilitating influence on the performance as a whole. As one hand of hemiplegic subjects is paralysed, we feel that this disability is bound to affect the skilled action performed by the other hand.

There is a very marked difference between the S.R.T. of deteriorated subjects and the undifferentiated group. Five of these subjects, according to nursing staff reports, are gradually deteriorating as far as their general behaviour is concerned; neurological examination, however, did not reveal any specific cause or causes responsible for their deterioration. The sixth of those subjects is the case of incipient schizophrenia. Because of their very long S.R.T.'s that group has also been excluded from further experiments.

There seems to be no significant difference between the S.R.T. of post-encephalitics and the undifferentiated group. Although there is often observed very marked deterioration in the apperance and general behaviour of post-encephalitics as their age advances, their S.R.T. seems to remain unaffected. We did measure additionally the S.R.T. of the two available post-encephalitics with the I.Q's 91 and 99 and it was found that their S.R.T. are within normal limits. This group was also excluded from the next experiment, not on the basis of their S.R.T. results but because of anticipation that their other results in the intended experiment might be somehow affected, being, therefore, atypical for the investigated group as a whole.

Discussion of the S.R.T. results of the epileptic group seems to be a very complicated task because of the presence of many variables which, undoubtedly, influence the obtained results. Some of them could be ascertained to a certain extent only, some of them are still defeating an experimental approach. Because of so many variables involved, undoubtedly influencing the relationship between epilepsy and S.R.T., and because of the relatively small number of epileptics investigated, the result given in the table below should be considered as tentative only.

S.R.T. is given in milliseconds.

	Mean of S.R.T.						Total mean of S.R.T. for the three groups of subjects.	Total Nr of subjects
	Subjects without fits and drugs in the last 12 months.	Nr of subjects.	Subjects without fits but on specific drugs.	No of subjects.	Subjects with fits and on specific drugs.	No of subjects		
Subjects who can draw an obtuse angle.	220.5	5	340.5	8	291.1	8	286.3	21
Subjects who can not draw and obtuse angle.	584	4	524.1	8	371	2	293.3	14

On the whole the S.R.T. results of the epileptic group, both the sub-group consisting of subjects who can draw an obtuse angle and the sub-group made up of subjects who cannot do this, are below the results obtained with the two corresponding sub-groups of undifferentiated mental defectives. Although the group of epileptics, because of the relatively low results obtained in S.R.T. experiment, has to be excluded from further experiments, we feel, that these results and their possible determinants should be discussed more fully at this stage.

Let us consider at first the results of the experiment as illustrated in the above table. The results of epileptics who can draw an obtuse angle and who had no fits and drugs in the last 12 months are slightly better (220.5 milliseconds) than the results of the corresponding undifferentiated sub-groups (242.5 milliseconds). This slight discrepancy between the above given results could be probably explained by the size of two groups involved: There are only 5 epileptics in the group under consideration while 60 subjects in the undifferentiated group. There is a sharp decline in the results (340.5 m/sec) of the S.R.T. of those epileptics who can draw an obtuse angle and who had not fits in the last twelve months but who are on specific drugs.[x] This decline in their results could be explained as due to the influence of drugs.

The results of the next group of epileptics, i.e. who are able to draw an obtuse angle, and who have fits and are on the specific drugs, are better (297.1 m/sec) than the previous group (340.5 m/sec) and are most interesting. The difference in the results of the S.R.T. between the last two groups of epileptics can be well interpreted as both groups are of the same size, approximately on the same intelligence level and showing the same drawing ability. It seems reasonable to put forward the following assumption: the specific drugs, used for the treatment of epilepsy, have a suppressing effect on the physiological reactions of an individual, whilst the epileptic fits have just the opposite, stimulating effect on these reactions. The above assumption can be supported by the experimental evidence obtained not only with the group of epileptics who can draw an obtuse angle, but also with the group of epileptics who cannot do this. In both these groups, subjects with fits and on drugs obtained better results in the S.R.T. experiment (297.1M/sec) and 371 m/sec) than the two respective groups of epileptics who had no fits but who are on drugs (340.5 m/sec and 524.1 m/sec). It should also be mentioned that the social behaviour of an epileptic seems to be somehow related to the cycle of his fits: it is usually much better immediately after than prior to the seizure.[ø]

There is one point in the table of the S.R.T. results of epileptics which should be discussed here, namely, the results of the group of subjects who were unable to draw an obtuse angle

x Epanutin, mysoline, luminal, amphetamine, cytamen, phenobarbitone and doriden.

ø Hoch, P.H. and Knight, R.P., Epilepsy, New York, Grune and Stratton, 1947.

and who had no fits or drugs in the last twelve months. The mean of that group is the lowest in the whole table. It seems that the only possible explanation of their unduly long S.R.T. is the prolonged treatment by the drugs to which they have been subjected previously and their advanced deterioration because of the increase in their age. It should also be remembered that, as this group is numerically small, chance may play a considerable role.

After the discussion of the results obtained in the S.R.T. experiment on the epileptic subjects let us mention briefly the difficulty of an experimental approach to the study of the relationship between the S.R.T. and epilepsy and possible variables involved in that particular problem. It seems to be clear from the results obtained that epileptic fits have an excitatory effect on the physiological reactions of an individual; it does not mean, however, that his S.R.T. would be within normal limits, even if he has had no drugs. The difficulty of the experimental study into the effects of fits on the S.R.T. is this: there are no available subjects in hospital who have fits and who are not on drugs. Such a subject could hardly be found in this country. If we accept that the presence of epileptic fits affects somehow adversely the S.R.T., then we have to consider their frequency and intensity. There could be little doubt that frequent and intense fits have greater effect on the S.R.T. than the sporadic and slight ones. Frequency of fits could be easily ascertained as each epileptic has a special card on which this frequency is recorded. Intensity of fits is also recorded on the same card, but because of the lack of objective standards in the assessment of their degree, all available data with regard to the intensity of fits are of very limited value.

The next difficulty in the experimental study of the relationship between fits and the S.R.T. is the irregularity with which fits occur. As the behaviour of an individual patient varies considerably between his two subsequent fits, his S.R.T. could also vary. It would be necessary to measure the S.R.T. of each patient every day between his two fits in order to determine the range and mean value of his S.R.T. Even then, the problem could still be complicated, because of effect of practice and the possible variations in intensity between his two subsequent fits.

The exact study of the effect of drugs on the S.R.T. is again a very complicated task, because of the variety of drugs used in the treatment of epilepsy, in our group.

The group of patients under consideration was treated with epanutin, mysoline, luminal, amphetamine, cytamen, phenobarbitone and doriden. All these drugs are supposed to have some beneficial effect on epilepsy; their side-effects, however, may be as varied as their effects on the S.R.T.

There seems to be another important factor affecting the S.R.T. of some epileptics, namely their age. It was not possible to find any experimental evidence that age affects the S.R.T. when considering the whole group of defectives subjected to the above experiment. Nevertheless, this factor seems to be important with deteriorated patients, whether deteriorated because of unknown reasons or whether deteriorated because of epilepsy. It is probably not so much an increase in age which affects the S.R.T. as the advance in deterioration which is often parallel to the age increase.

Last, but not least, we should also mention that the various types of epilepsy, as for example, idiopathic and temporal lobe epilepsy, may affect the S.R.T. in different ways.

Summing up; in the experimental study of the effects of epilepsy on the S.R.T. the following factors and their inter-relationship should be considered; the type of epilepsy, the frequency and intensity of fits, the mean of the S.R.T. between the two subsequent fits, the type of drugs used and the degree and rate of deterioration of an individual patient.

After the consideration of the results of the S.R.T. of various more or less clinically distinct groups, it was decided to confine the further investigation to the group of 120 undifferentiated defective subjects and to the control group composed of nursing staff.

CHAPTER V.

THE MAIN EXPERIMENT.

In the main experiment the three following tests were included:

(a) Pressure and Drawing Performance Time Test.

(b) Drawing Test.

(c) Verbal, Performance and scholastic attainment test.

1. Purpose of the experiment.

The main purpose of this experiment was to obtain data from the three groups of subjects on their hand-pressure and drawing performance time. The results obtained from this experiment, and the results from the S.R.T. test, could then be compared in order to see whether there are statistically significant differences between these three groups. It would also be possible to discover whether there is any correlation between the results from the various experiments within each group. The secondary purpose of the main experiment was to explore more closely the drawing ability within the two defective groups. It was necessary to re-check the results obtained in the preliminary drawing experiments and to investigate the quantitative aspects of the improvement of the drawing and the tendency to draw the figures smaller, which are particularly manifested when the three drawings of each presented figure have to be performed by each patient.

Finally, we wanted to compare the two defective groups on their scores in the verbal and performance tests, and their simple scholastic attainments, such as the ability to read and write.

2. Selection of subjects and division of them into three groups.

The experiment was carried out on 180 adult subjects, 120 of them were certified mental defectives, the remaining 60 were members of the nursing staff. Mental defective subjects were selected on the basis of their results in the preliminary experiments and particularly on the basis of the S.R.T. test. All defective subjects were divided according to their drawing ability, into two groups: Group I was composed of 60 subjects, 30 male and 30 female patients, who were unable to draw an obtuse angle in the preliminary test; Group II was made up of 60 subjects, 30 male and 30 female patients who were able to draw an obtuse angle. Both groups contained clinically undifferentiated subjects. There were no hemiplegic, post-encephalitic, epileptic or deteriorated patients among them. The results of the S.R.T. test obtained with both these groups are given in the previous chapter under heading: "Undifferentiated Patients". The results obtained in all subsequent tests were arranged exactly in the same order as the results of the S.R.T. test, so that the data obtained in any of those tests, by any patient, could be easily traced in the respective tables. The I.Q.'s of both defective groups, as measured by the Revised Stanford-Binet Intelligence Scale, Form L, varied between 38 and 57. The third group used in the main experiment was composed of 60 members of the nursing staff, 30 males and 30 females, and they were selected by the Chief Male Nurse and Matron respectively. It should be mentioned here that the group of nursing staff which took part in the S.R.T. test was not made up of exactly the same subjects as the third group used in the present experiment.*

3. Instruments, procedures and results.

A) Pressure and Drawing Performance Time test.

The pressure and drawing performance time tests were carried out as follows: a wooden box 8 x 5 inches square and

* Because some nurses were on shift duties, holiday or sick leave.

2 inches high was used. (Figure 4). From the base of the box, in each corner, projected a perpendicular $\frac{1}{4}$ inch brass tube. A rubber tube (similar to those used in the fountain pen) $\frac{3}{4}$ inch in length was fitted on each rod with the upper end of each sealed. Over each rubber tube was fitted a spiral spring resting on the base and finishing level with the top of the rubber tube. A sheet of perspex was fitted to the top of the box resting on the four springs and rubber endings. Rubber tubing was connected to the four projecting ends of the brass tubes in the base of the box and these were connected to a single thick rubber tube leading to a round tambour fitted with a pointer. On a similar principle the writing instrument was connected by the thick rubber tube to the same tambour. This box was fitted in an 8 x 8 inch square aperture in the table top in such a way that the top surface of the perspex was flush with the top surface of the table. A piece of sheet metal 12 x 12 inches with a 3 x $4\frac{1}{2}$ inch aperture in the centre was placed on the table with the aperture directly over the box. On another table was a Kymograph. Beside it was placed an Electric Time Clock connected to another marker (Figure 5). There were also three pieces of white cardboard, 3 x 4 inches with a drawing of an acute angle, a right angle, and an obtuse angle respectively on them. These were then placed on the table containing the box described above. Immediately before the beginning of an experiment a piece of white paper was fixed on the perspex, a marker connected to the box and writing instrument was made to touch the smoked drum in a position approximately one third from the top of the drum. The drum was then set in motion and a base line was drawn by the marker on the smoke-covered paper around the drum. When the line was completed, the instrument was stopped and instructions were given to the subject, sitting comfortably by the table, to draw in a single movement an acute angle on the paper in the window, exactly the same as the drawing on the piece of white cardboard

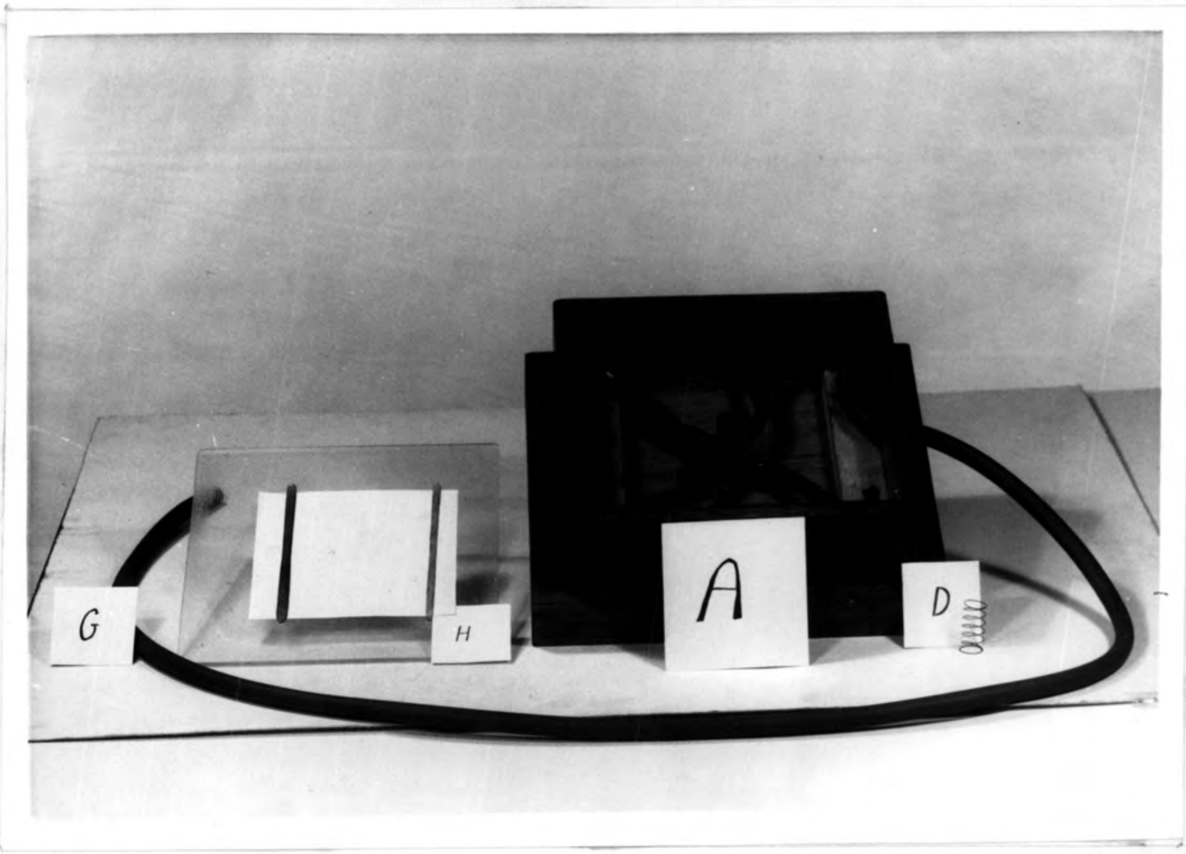

Figure 4. Pressure-sensitive box. A-Box. H-Cover of perspex with drawing paper fixed. G-Rubber tube leading to marker. D-One of the four springs supporting cover.

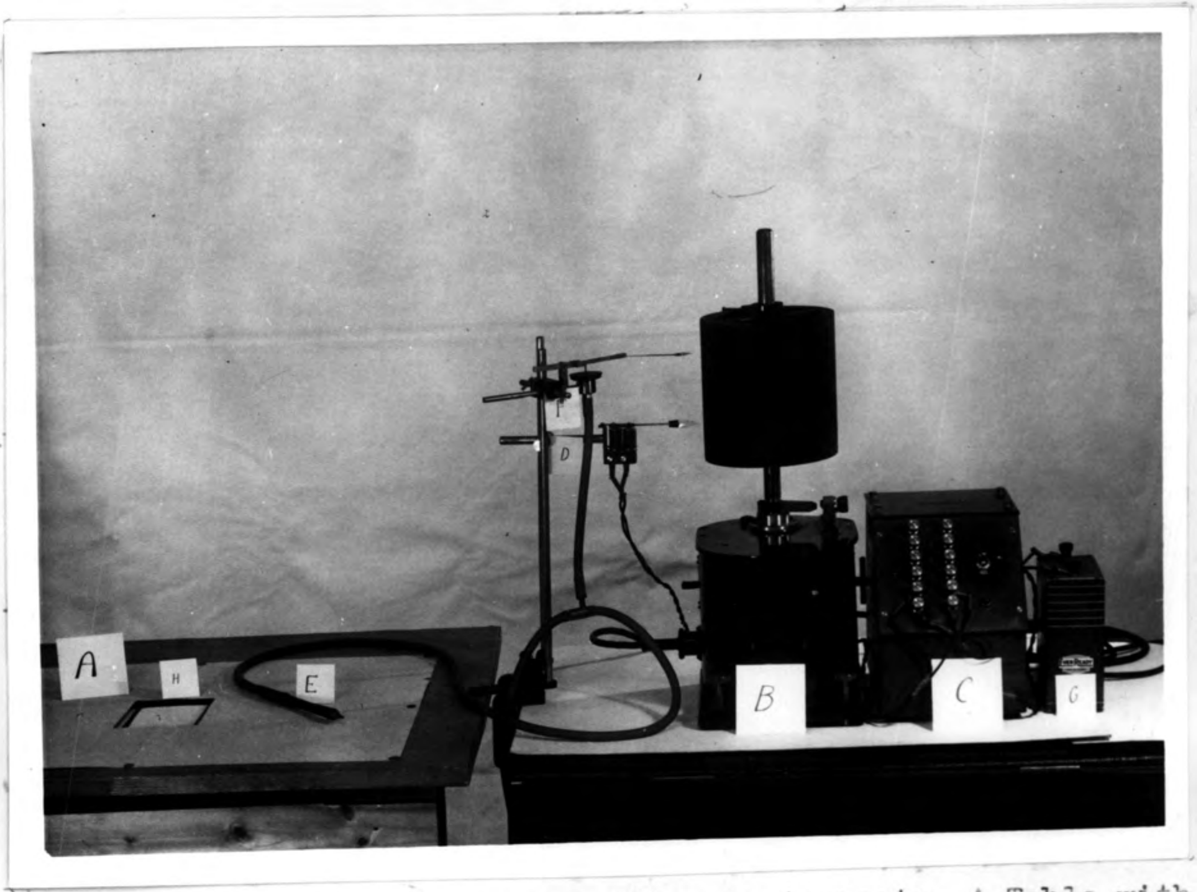

Figure 5. Set of pressure recording instruments. A-Table with pressure-sensitive box inside. B-Kimograph. C-Electric Clock. H-Drawing window. E-Writing pen. F-Pressure marker. D-Time marker. G-Battery.

placed on the table before his eyes. Then the writing instrument was handed to him and the drum set in motion. When he had finished drawing an acute angle, the drum was stopped, the pointer removed, the drawing paper in the window changed, the marker put in position about half way down the drum, and the drawing of a right angle and an obtuse angle followed exactly as described above. The pressure exerted during the drawing on the perspex surface by the writing instrument and also the pressure of the fingers on the writing instrument pneumatically transmitted to the marker and registered on the smoke-covered paper on the revolving drum, as a curve beginning and ending on the base line. When the three drawings were completed, the pointer connected with the Electric Time Clock was put just below the last base line and the drum set in motion again, providing a time base to the record. The speed of the drum was constant in all experiments. When the pressure of the three drawings and the time had been recorded, the smoke-covered paper was removed from the drum, put into a solution of shellac and methylated spirits and allowed to dry. By using a planimeter we were able to measure in square inches the area between the base line and the curve due to pressure exerted during the drawing. By using two parallel lines at the beginning and the end of the pressure-curve, we could measure the performance time for each angle.

As the pressure recording instrument had been calibrated, the exact ratio is known between any given weight placed on the perspex and the linear value of the pointer deflection. Having also the pressure for any drawing expressed in square inches, and the performance time, it is easy to calculate the average pressure exerted during the drawing in weight units per second. The results of the Pressure and Performance Time tests obtained with the two groups of defectives and one group of nursing staff are given below.

Results of the Pressure test obtained with Group I.

(Mental defective subjects who were unable to draw an Obtuse angle).

Number of subject	Pressure in square inches exerted during the drawing of: Acute angle	Right angle	Obtuse angle	Sum of pressures for the three angles.
1	2 15	8 45	5 57	16 17
2	3 00	2 28	1 39	6 67
3	0 91	5 64	2 54	9 09
4	7 18	4 22	2 48	13 88
5	5 80	5 24	5 98	17 02
6	2 66	3 53	4 26	10 45
7	1 72	2 07	3 26	7 05
8	2 22	1 23	1 29	4 74
9	11 50	3 74	7 05	22 29
10	3 36	2 20	3 58	9 14
11	4 33	2 16	3 19	9 68
12	8 35	7 86	6 92	23 13
13	11 70	8 00	8 56	28 26
14	15 19	6 05	8 08	29 32
15	5 28	5 94	8 66	19 88
16	3 00	4 62	3 70	11 32
17	3 95	4 41	3 93	12 29
18	1 30	4 05	4 89	10 24
19	2 49	3 43	3 64	9 56
20	7 76	5 90	8 87	22 53
21	4 15	2 64	3 48	10 27
22	3 94	5 02	6 08	15 04
23	7 86	6 37	10 49	24 72
24	3 15	5 34	1 21	9 70
25	7 95	3 60	5 80	17 35
26	6 85	3 33	10 55	20 73
27	2 87	2 20	3 92	8 99
28	10 00	6 44	6 10	22 54
29	5 67	10 39	4 80	20 86
30	9 76	19 64	9 65	39 08
31	4 06	5 32	5 34	14 72
32	2 42	7 15	5 80	15 37
33	2 00	3 41	5 34	10 75
34	3 60	3 51	3 60	9 71
35	7 75	15 75	9 05	32 55
36	2 29	4 25	6 14	12 68
37	1 66	2 69	2 05	6 40
38	5 56	9 40	8 00	22 96
39	0 94	1 12	4 49	6 72
40	6 54	4 82	9 04	20 40
41	4 14	9 67	16 19	30 00
42	6 02	5 38	7 80	19 20
43	3 60	6 59	6 22	16 41
44	5 40	3 85	5 38	13 63
45	2 67	3 28	7 21	13 16
46	2 05	2 11	3 26	7 42
47	3 16	9 23	10 06	22 45
48	4 55	6 77	4 81	16 13
49	2 19	1 82	7 40	11 41
50	1 71	2 90	6 30	10 91
51	2 33	1 62	1 71	5 66
52	0 98	1 58	5 03	7 59
53	4 44	1 90	3 06	9 40
54	18 25	16 23	17 14	51 62
55	3 96	2 71	5 86	12 53
56	1 59	1 45	5 37	8 41
57	1 86	4 60	5 18	11 64
58	1 43	4 70	7 29	13 42
59	1 80	4 34	1 98	8 12
60	4 25	7 41	10 29	21 95

* For all significances of differences between means of groups - see chapter VI.

Results of the Pressure Test obtained with Group II.

(Mental defective subjects who were able to draw an obtuse angle.)

Number of subject	Pressure in square inches exerted during the drawing of : Acute angle	Right angle	Obtuse angle	Sum of pressure for the three angles.
1	0 35	0 29	1 19	1 83
2	0 85	3 48	1 64	5 97
3	0 80	3 28	5 63	9 71
4	0 30	0 38	0 40	1 08
5	1 53	2 70	3 78	8 01
6	1 19	1 25	1 40	3 84
7	0 67	0 55	0 96	2 18
8	3 50	4 85	4 70	13 05
9	1 41	1 02	1 20	3 63
10	1 00	2 94	3 10	7 04
11	2 79	1 62	0 55	4 96
12	0 55	1 55	0 55	2 65
13	0 54	1 62	1 04	3 20
14	1 03	0 49	0 83	2 35
15	0 66	1 02	1 36	3 04
16	0 69	0 60	1 18	2 47
17	0 30	1 41	1 11	2 82
18	2 06	1 39	1 38	4 83
19	0 74	1 85	0 80	3 39
20	2 48	2 95	2 96	8 39
21	0 44	0 50	0 34	1 28
22	3 97	2 26	1 17	7 40
23	2 50	2 28	2 83	7 61
24	2 20	4 68	3 13	10 01
25	1 95	3 48	3 75	9 18
26	2 08	3 25	1 48	6 81
27	0 94	0 46	0 88	2 28
28	1 09	0 46	2 57	4 12
29	0 73	3 16	2 60	6 49
30	0 79	1 02	0 46	2 27
31	0 56	1 51	1 69	3 76
32	0 98	1 50	1 26	3 74
33	1 69	1 00	0 35	3 04
34	0 41	0 85	0 91	2 17
35	0 63	1 85	2 08	4 56
36	0 37	0 23	0 40	1 00
37	1 11	2 34	1 60	5 05
38	2 52	0 45	0 30	3 27
39	0 39	0 40	1 19	1 98
40	0 20	0 05	0 35	0 60
41	1 99	3 74	2 46	8 19
42	0 67	1 04	1 00	2 71
43	1 31	1 00	0 66	2 97
44	0 67	0 34	0 29	1 30
45	4 85	2 17	1 69	8 71
46	0 35	1 06	1 05	2 46
47	0 26	0 24	0 67	1 17
48	0 71	1 83	2 44	4 98
49	1 05	0 55	0 75	2 35
50	0 25	0 30	0 95	1 50
51	0 33	0 62	1 56	2 51
52	0 58	0 83	2 68	4 09
53	0 70	4 60	0 94	6 24
54	0 12	0 21	0 98	1 31
55	3 80	4 10	2 85	10 75
56	0 64	0 47	1 96	3 07
57	1 04	0 91	1 25	3 20
58	0 58	0 76	1 02	2 36
59	2 80	3 71	3 87	10 38
60	1 15	0 94	1 26	3 35

Results of the Pressure Test obtained with the Group composed of Nursing Staff.

Number of subject.	Pressure in square inches exerted during the drawing of Acute angle	Right angle	Obtuse angle	Sum of pressure for the three angles.
1	0 85	1 10	1 64	3 59
2	0 81	1 34	1 30	3 45
3	0 55	0 28	0 31	1 14
4	0 47	0 21	0 57	1 25
5	0 79	0 37	0 45	1 61
6	0 30	0 65	0 17	1 12
7	0 34	0 35	0 22	0 91
8	4 73	1 81	1 28	7 82
9	0 72	0 44	0 59	1 75
10	2 19	1 45	1 39	5 03
11	1 45	0 70	1 10	3 25
12	1 19	2 24	4 30	7 73
13	0 47	0 49	0 32	1 28
14	0 51	0 53	0 73	1 77
15	0 81	1 73	0 58	3 17
16	0 45	0 68	0 39	1 52
17	0 81	0 60	0 68	2 09
18	1 70	0 81	0 14	2 65
19	1 64	1 59	1 40	4 63
20	0 82	0 76	1 74	3 32
21	0 86	1 04	1 00	2 90
22	2 92	1 82	1 34	6 08
23	2 60	2 14	2 19	6 93
24	0 87	0 23	0 15	1 25
25	0 97	1 26	0 94	3 17
26	1 12	1 16	0 90	3 18
27	3 19	1 38	2 55	7 12
28	0 29	0 15	0 38	0 82
29	1 10	0 65	1 14	2 89
30	1 16	1 12	1 35	3 63
31	0 24	0 55	1 06	1 85
32	1 22	1 14	1 67	4 03
33	2 31	0 35	0 32	2 95
34	0 50	0 56	0 61	1 67
35	0 45	0 43	0 22	1 16
36	1 11	0 23	0 21	1 55
37	1 41	1 50	2 56	5 47
38	0 05	0 35	0 63	1 03
39	3 17	3 92	0 94	8 03
40	1 90	1 82	1 99	5 71
41	0 27	1 23	0 83	2 33
42	0 92	0 25	0 95	2 12
43	0 96	1 24	1 81	4 01
44	0 82	1 65	1 04	3 51
45	0 24	0 22	0 20	0 66
46	0 11	0 14	0 35	0 60
47	3 21	1 15	0 40	4 76
48	1 15	1 44	2 05	4 64
49	2 58	1 61	2 09	6 28
50	0 51	0 75	1 01	2 27
51	0 78	0 56	0 77	2 11
52	1 20	1 04	1 97	4 21
53	0 66	1 29	1 06	3 01
54	0 80	0 56	0 95	2 31
55	0 50	0 54	0 35	1 39
56	0 17	0 15	0 11	0 43
57	1 80	0 55	0 54	2 89
58	5 29	2 33	1 95	9 57
59	0 12	0 15	0 24	0 51
60	0 78	1 40	0 65	2 83

Results of the Performance Time Test obtained with Group I.

(Mental defectives who were unable to draw an obtuse angle.)

Number of subject	Drawing Performance Time (to the nearest 1/3 sec.) for: Acute angle	Right angle	Obtuse angle	Sum of Performance Times for the three angles
1	8 33	12 33	7 66	28 33
2	14 00	7 00	8 66	29 66
3	8 66	12 33	8 00	29 00
4	12 00	7 00	6 33	25 33
5	8 66	6 66	7 00	22 33
6	7 33	8 66	6 66	22 66
7	7 33	9 33	11 00	27 66
8	7 33	8 33	9 66	25 33
9	24 00	12 66	10 66	47 33
10	16 66	10 66	9 33	36 66
11	21 00	11 66	10 33	43 00
12	14 00	13 00	13 33	40 33
13	22 00	12 66	11 66	46 33
14	16 00	12 00	11 66	39 66
15	10 33	6 00	9 00	25 33
16	19 33	9 66	12 00	41 00
17	11 00	4 66	7 00	22 66
18	8 66	7 00	7 66	23 33
19	8 66	5 66	7 33	21 66
20	9 33	10 66	8 66	28 66
21	10 00	6 66	7 33	24 00
22	8 00	10 00	11 00	29 00
23	8 66	4 66	10 00	23 33
24	8 00	8 33	7 66	24 00
25	14 00	10 33	12 33	36 66
26	21 33	19 00	17 66	58 00
27	7 33	5 66	7 33	20 33
28	12 66	9 66	10 00	32 33
29	14 33	13 00	10 66	38 00
30	13 00	17 33	17 33	47 66
31	9 33	9 00	10 66	29 00
32	8 00	10 66	7 33	26 00
33	7 33	5 33	8 00	20 66
34	7 66	8 33	5 66	21 66
35	16 66	15 00	11 00	42 66
36	8 66	7 00	7 00	22 66
37	5 33	4 66	4 33	14 33
38	13 00	9 00	8 00	30 00
39	11 66	6 00	8 33	26 00
40	7 66	8 00	10 00	25 66
41	8 66	11 33	15 33	35 33
42	9 00	7 00	8 66	24 66
43	10 00	11 00	9 00	30 00
44	8 33	7 33	10 66	26 33
45	6 33	7 00	10 33	23 66
46	6 66	4 66	5 66	17 00
47	7 33	9 00	11 66	28 00
48	11 66	12 66	10 00	34 33
49	12 00	10 66	15 00	37 66
50	7 66	7 33	11 00	26 00
51	6 33	6 00	6 00	18 33
52	4 00	5 00	8 00	17 00
53	7 33	6 00	7 00	20 33
54	10 66	9 66	10 66	31 00
55	7 00	4 66	6 00	17 66
56	4 66	3 33	7 66	15 66
57	6 66	6 33	6 33	19 33
58	8 00	9 66	13 00	30 66
59	10 66	6 33	6 33	23 33
60	11 33	12 33	16 66	40 33

Results of the Drawing Performance Time obtained with Group II.

(Mental defectives who were able to draw an obtuse angle.)

Number of subject	Drawing Performance Times (to the nearest 1/3 of second). for: Acute angle	Right angle	Obtuse angle	Sum of Performance Times for the three angles
1	6 66	2 66	5 33	14 66
2	8 66	6 33	7 00	22 00
3	8 33	6 33	6 00	20 66
4	7 00	10 00	8 66	25 66
5	9 00	9 00	6 66	24 66
6	6 33	3 66	3 00	13 00
7	12 66	7 00	7 33	27 00
8	10 00	9 66	10 66	30 33
9	10 33	11 66	11 33	33 33
10	10 66	11 66	10 66	33 00
11	7 00	7 66	6 66	21 33
12	11 66	9 66	10 00	31 33
13	3 66	4 66	5 33	13 66
14	7 33	4 66	6 66	18 66
15	5 33	5 33	6 33	17 00
16	5 33	3 00	5 00	13 33
17	4 66	6 33	5 66	16 66
18	8 33	5 00	5 66	19 00
19	5 33	3 66	4 33	13 33
20	9 33	6 66	6 33	22 33
21	12 33	6 66	7 00	26 00
22	10 00	6 00	5 00	21 00
23	5 33	5 00	5 66	16 00
24	7 33	6 00	5 66	19 00
25	7 33	6 00	6 66	20 00
26	8 00	4 66	5 66	18 33
27	6 33	5 00	8 33	19 66
28	4 66	5 00	8 00	17 66
29	4 66	10 00	7 33	22 00
30	4 00	4 33	3 66	12 00
31	5 00	4 00	4 00	12 00
32	4 66	7 66	6 00	18 33
33	3 66	2 66	2 33	8 66
34	5 00	7 00	9 66	21 66
35	6 00	3 66	4 00	13 66
36	5 66	2 66	3 00	11 33
37	5 33	5 66	4 66	15 66
38	6 00	4 00	5 66	15 66
39	4 00	4 00	3 66	11 66
40	4 00	1 33	3 33	8 66
41	6 66	6 00	7 00	19 66
42	6 66	6 66	8 66	22 00
43	8 33	5 00	5 33	18 66
44	12 00	15 66	14 66	42 33
45	6 33	5 00	4 66	16 00
46	3 33	4 33	3 33	11 00
47	5 33	3 33	4 33	13 00
48	6 66	5 00	9 66	21 33
49	6 33	2 00	2 33	10 66
50	2 66	2 66	3 66	9 00
51	4 00	4 66	5 66	14 33
52	6 33	4 66	6 33	17 33
53	3 66	5 00	8 33	17 00
54	3 33	3 33	7 33	14 00
55	9 00	9 66	9 66	28 33
56	6 66	6 33	8 66	21 66
57	3 00	2 66	4 33	10 00
58	3 33	3 00	3 00	9 33
59	11 33	6 66	6 66	24 66
60	5 00	3 66	5 33	14 00

Results of the Performance Times test obtained with the group of nursing staff.

Number of Subject.	Drawing Performance Time (to the nearest 1/3 of second.) for: Acute angle	Right Angle	Obtuse angle	Sum of Performance Times for the three angles.
1	5 66	6 66	6 33	18 66
2	4 00	5 33	2 66	12 00
3	4 00	2 33	2 66	9 00
4	5 00	2 33	3 33	10 66
5	2 00	8 00	1 66	11 66
6	2 66	2 33	2 66	7 66
7	2 33	2 33	2 00	6 66
8	5 66	6 33	6 00	18 00
9	1 33	1 66	2 00	5 00
10	4 00	3 66	6 33	14 00
11	4 66	5 66	6 00	16 33
12	2 66	2 33	2 66	7 66
13	3 66	3 00	2 66	9 33
14	2 66	2 33	3 00	8 00
15	2 66	2 66	4 00	9 33
16	3 33	3 66	2 66	9 66
17	7 00	7 00	7 33	21 33
18	4 00	8 00	3 66	15 66
19	8 33	9 00	11 33	28 66
20	3 33	5 33	5 00	13 66
21	2 66	3 00	2 00	7 66
22	10 33	8 00	9 33	27 66
23	7 33	5 00	5 00	17 33
24	3 33	2 66	1 66	7 66
25	2 33	2 33	2 33	7 00
26	3 00	3 00	2 66	8 66
27	4 33	4 00	5 66	14 00
28	4 00	2 33	3 33	9 66
29	1 33	1 00	1 33	3 66
30	1 66	1 66	2 33	5 66
31	2 33	2 66	3 66	8 66
32	1 66	2 33	3 33	7 33
33	3 66	3 33	3 00	10 00
34	2 33	3 66	2 33	8 33
35	5 66	2 66	2 00	10 33
36	2 00	1 66	1 00	4 66
37	2 66	2 66	4 33	9 66
38	1 66	3 66	5 66	11 00
39	3 66	4 33	4 33	12 33
40	5 00	4 66	5 66	15 33
41	2 00	2 00	2 66	6 66
42	3 66	3 66	4 00	11 33
43	2 66	4 33	3 33	10 33
44	3 33	3 33	3 33	10 00
45	3 00	2 66	2 66	8 33
46	1 66	2 66	1 33	5 66
47	5 66	5 33	5 66	16 66
48	5 00	6 33	5 00	16 33
49	4 00	4 66	5 66	14 33
50	6 66	6 00	7 33	20 00
51	3 00	2 66	2 66	8 33
52	5 00	4 00	4 00	13 00
53	6 66	5 00	9 66	21 33
54	4 33	4 33	4 00	12 66
55	5 00	5 00	3 33	13 33
56	1 66	1 33	1 66	4 66
57	2 66	3 00	2 66	8 33
58	9 00	6 33	6 66	22 00
59	2 33	2 00	2 66	7 00
60	3 33	3 00	2 00	8 33

Certain characteristic features of the pressure curves.

In figure 6 are photographs of the three pressure curves for acute, right and obtuse angles obtained with three subjects. The record marked 129 was obtained with a mental defective subject from Group I. The record 272 was obtained with a subject belonging to Group II. The record 306 with a member of the nursing staff. Although there are wide variations with regard to the volume of pressure used during the drawing, performance time, and the shape of the curves obtained between various subjects within the same group, nevertheless the three records could be considered to be broadly representative samples of the three groups under investigation. The primary difference between the pressure curves obtained with the various groups is the volume of the pressure used and the performance time. These differences were apparent even without performing any quantitative measurements. There are also the secondary differences in the shape of the curves, particularly between records obtained with Group I and Group II.

These secondary differences could be observed in the majority of records and also in Figure 6. It seems that the preparatory time for the drawing of any particular angle would be somewhat longer in Group I than it is in Group II and the group of nursing staff. By the preparatory time is meant the time interval between the subject being handed the writing instrument and his commencing to draw. As the writing instrument is pressure sensitive, any hesitation or slow start would be recorded as a flat or very slow rising curve above the base line.

In the majority of records performed by subjects belonging to Group I, this preparatory time is quite obvious. On the other hand nursing staff or subjects belonging to the Group II begin to draw immediately after the writing instrument

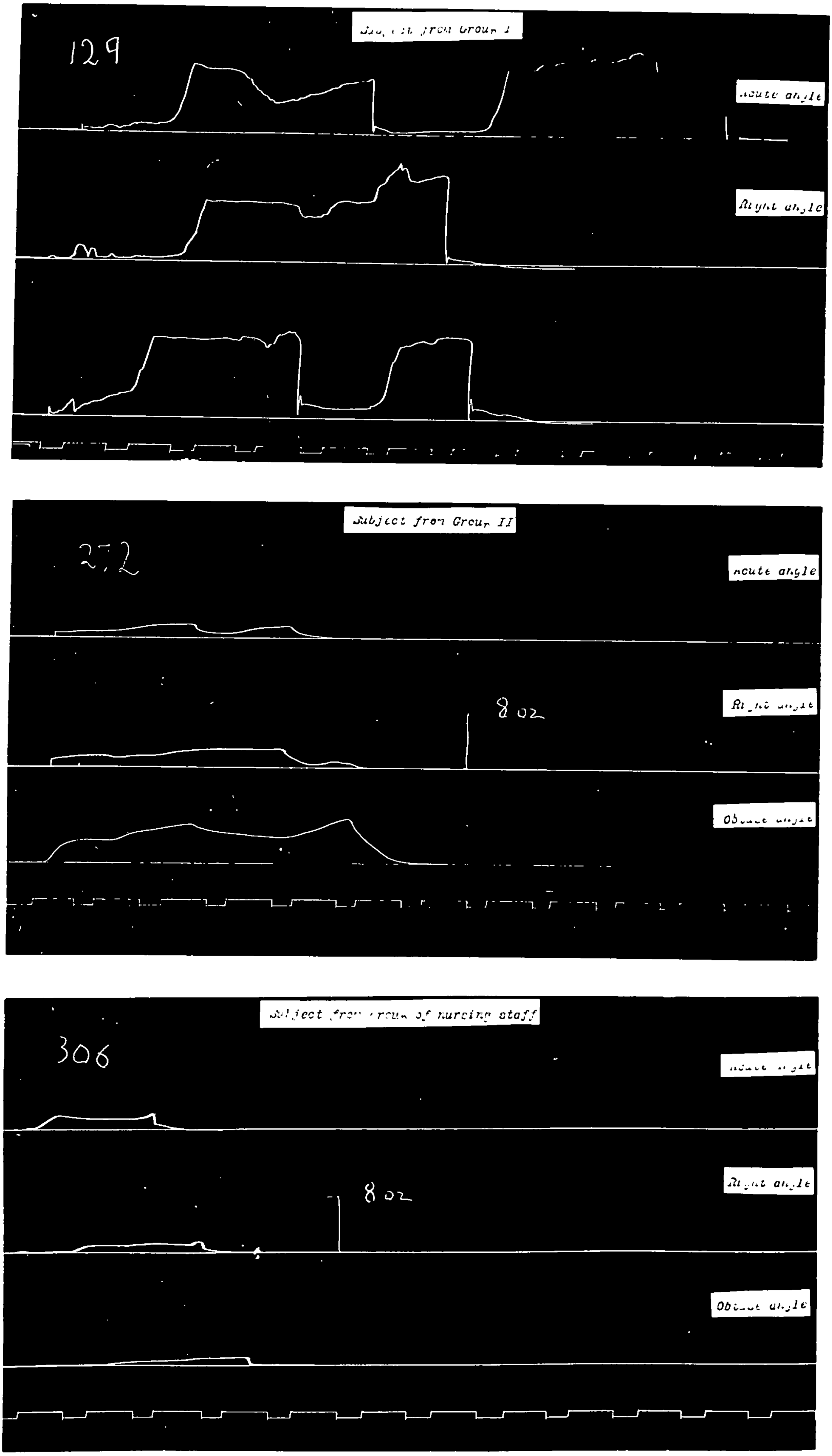

Figure 6. Pressure-curves [illegible] th [illegible] levels [illegible] tal level [illegible]

is handed to them and their records do not show these flat lines preceding the drawings. The presence of this preparatory time in Group I could be explained as the prolonged period in which the formation of motor patterns is completed. The subjects of Group II and the nursing staff Group seem to form these motor patterns when instructions are given and a demonstration performed by the experimenter. But this time is obviously insufficient for Group I, and, therefore, they complete the formation of motor patterns in the time provided for drawing.

Another difference which could be easily observed between the records of Group I and Group II is the shape of the pressure curves. The shape of the pressure curves are relatively smooth and slowly increasing or decreasing in Group II and the nursing staff Group, while the shapes in Group I are uneven, showing many sudden changes. These sudden variations in the pressure are probably due to the greater degree of difficulty in performing the necessary changes in direction of the moving hand and the inability to maintain steady pressure by those subjects in Group I.

B. Drawing Test.

This test was essentially very similar to the preliminary drawing test; it was, however, extended in the hope of obtaining more information about the drawing behaviour of simple geometrical figures by the mentally defective subjects.

The purpose of the Drawing test was to obtain quantitative data in Group I and in Group II in order to compare these two groups with regard to:

(a) Ability or inability to draw various angles and a diamond.
(b) Type and frequency of drawing failures.
(c) Ability to improve imperfect drawing in the subsequent two attempts.

(d) Tendency to draw smaller angles or a diamond in each subsequent attempt.

For the drawing test foolscap papers were provided, each divided into four equal parts with an acute angle, a right angle, an obtuse angle and a diamond in that order printed on the left-hand side. Each mentally defective subject belonging to Group I or to Group II was asked to draw on the same paper opposite the printed figures, an acute angle, a right angle, an obtuse angle and a diamond. Three attempts were allowed. The same instructions were given as in the preliminary drawing test, i.e. "Draw these figures in one movement, like this"; (here the procedure was demonstrated) "keep your pencil on the paper while drawing, do not lift the pencil."

If even one of the three attempts to draw some angle or diamond was successful the subject was classified under the heading 'Drawing Success'.

(a) Table of successful drawing of the various angles and the diamond is given below.

		Number of drawing successes.			
	Nr of subj.	Acute ang.	Right ang.	Obtuse ang	Diamond
Group I	60	31	51	0	4
Group II	60	52	58	60	56

Two direct conclusions can be drawn from the results given in the above table, the first: that the ability to draw an obtuse angle is closely related to the ability to draw a diamond; the second that the drawing of different angles present varying degrees of difficulty. These results and their conclusions appear to confirm entirely our initial assumptions and conclusions drawn from the preliminary drawing experiments, There are however, some points in the above table, particularly with regard to the results obtained by Group II, which could be easily misinterpreted. It seems, judging from the results, that for the subjects belonging to Group II the most difficult task was to draw an acute angle. Nothing could be further from the truth. For the mental defective patients belonging to Group II the given task of drawing acute and right angles was subjectively so easy that they did not pay much attention to its correct execution. They have obtained the best results with the drawing of an obtuse angle and the diamond because these presented some difficulty for them and compelled them to exercise some effort. For these reasons the degree of difficulty involved in various drawings could be more correctly assessed by the combined results obtained with both groups.

(b) Type and frequency of drawing failures.

(i) Type of drawing failures and their frequency when an acute angle was presented.

Type of response.	Frequency	
	Group I.	Group II.
Both lines are rounded upwards	4	-
One line is rounded upwards.	11	-
Three lines are used.	4	-
Disconnected lines.	8	8
Crossed lines.	1	-
Right angle is drawn.	1	-
Total number of failures.	29	8

(ii) Type of drawing failures and their frequency when a right angle was presented.

Type of response.	Frequency	
	Group I.	Group II.
An acute angle is drawn.	3	1
Disconnected lines.	2	1
Crossed lines.	1	-
Angle is rounded upwards.	3	-
Total number of failures.	9	2

(iii) Type of drawing failures and their frequency when an obtuse angle was presented.

Type of response.	Frequency	
	Group 1.	Group II.
Straight line is drawn	2	-
Curved line, like a rounded obtuse angle.	14	-
Curved line, like a rounded acute angle.	6	-
Curved line, like a rounded right angle.	9	-
Right angle is drawn	13	-
Obtuse angle with crossed lines.	7	-
Acute angle is drawn	2	-
Acute angle with crossed lines.	3	-
Right angle with disconnected lines.	1	-
Acute angle ending with a long comma.	3	-
Total Nr. of failures.	60	-

(iv) The type of drawing failures when a diamond was presented are illustrated in Picture 7. The frequency of response is given in the table below.

Type of response as in Figure 7, drawing nr.	Frequency	
	Group I	Group II
1	2	2
2	10	1
3	6	1
4	2	-
5	7	
6	2	-
7	6	-
8	4	-
9	5	-
10	3	-
11	4	-
12	1	-
13	1	-
14	3	-
Total nr.of failures	56	4

Analysis of the drawing responses to various angles and a diamond obtained with the two groups of mental defective subjects confirm the results obtained in the preliminary experiments. Ability to draw some particular angle or a diamond seems to be chiefly determined by the mental development of an individual and particularly by his motor ability to perform certain changes in the direction of the moving hand. When an individual is given a task which is beyond his motor development, then he regresses to some lower motor level, thus employing a pattern developed previously. The level of his motor development, regressive patterns, and even some personality trends could be infered from the careful analysis of some drawing responses of mental defective subjects.

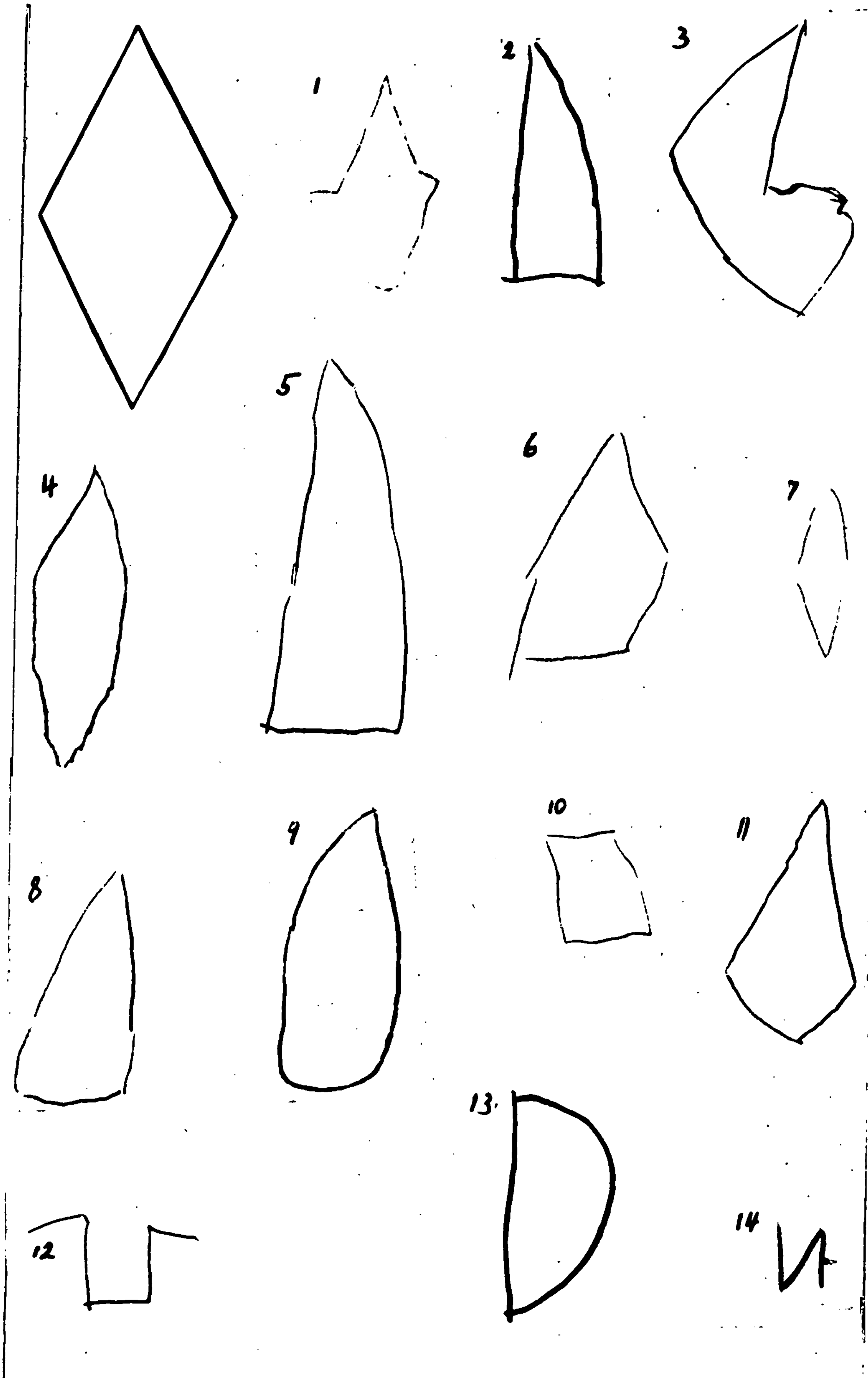

Figure 7. Drawing responses of fourteen mentally defective subjects when asked to copy a diamond.

(c) Ability to improve an imperfect drawing in the subsequent two attempts.

In the preliminary drawing test each subject was asked to draw various angles, and one attempt was allowed for each angle. In the present test each subject was asked to draw various angles and a diamond and three attempts were allowed. The purpose of the extension of the number of attempts allowed for each figure was to investigate the effects of practice. We were interested in how many subjects would show some improvement in their subsequent drawings of the same figure, and in which particular figures this improvement would be the most significant.

The results of the analysis of the drawings executed by the mentally defective grouped subjects are given in the table below.

Improvement in drawing due to practice.

	Nr of subj. under investigation	Nr of subj. showing improvement.	Improvement shown in Acute angle	Right angle	Obtuse angle	Diamond
Group I	60	13	10	8	0	1
Group II	60	25	11	1	12	9
Totals	120	38	21	9	12	10.

Two points in the above table seem to be of some importance. The number of subjects in Group II who show improvement is almost twice that of the corresponding number in Group I. There seems to be a significant difference between these groups as far as their ability to improve their drawing by practice, or modify their motor responses, is concerned. There is another interesting point in the above table, namely: the difference in the pattern of responses. There are significant differences between the numbers showing improvement in Group II with regard to right and obtuse angles and a diamond. Subjects of that group show almost equal capacity for improvement in drawing any of these figures. On the other hand subjects of Group I show improvement in acute and right angles. There is no improvement as far as an obtuse angle is concerned and only one subject improved his drawing of a diamond. On the whole, the results given in the above table point out not only the various degrees of improvement in both groups but also the various levels of motor development on which both groups are capable of improving their drawings.

(d) Tendency to draw smaller angles or diamonds in each subsequent drawing.

This phenomenon has been observed during routine testing with the test design for the seventh mental year in the Revised Stanford-Binet Intelligence Scale.

The results of the analysis of drawings performed by Group I and Group II are given in the table below.

Tendency to decrease in size each of the subsequent drawings.

	Nr of subjects under investigation.	Nr of subjects showing tendency to draw each subsequent figure smaller.	Figure showing the decreasing tendency.			
			Acute angle	Right angle	Obtuse angle	Diamond.
Group I	60	47	15	16	18	24
Group II	60	33	9	17	9	17
Totals	120	80	24	33	27	41

The results of this table show that there is some difference between Group I and Group II in the numbers of subjects showing a tendency to decrease the size of their drawing in each of the subsequent drawings. Unfortunately, we are unable to offer an adequate explanation of this phenomenon at present, or to explain the patterns of responses obtained with both groups.

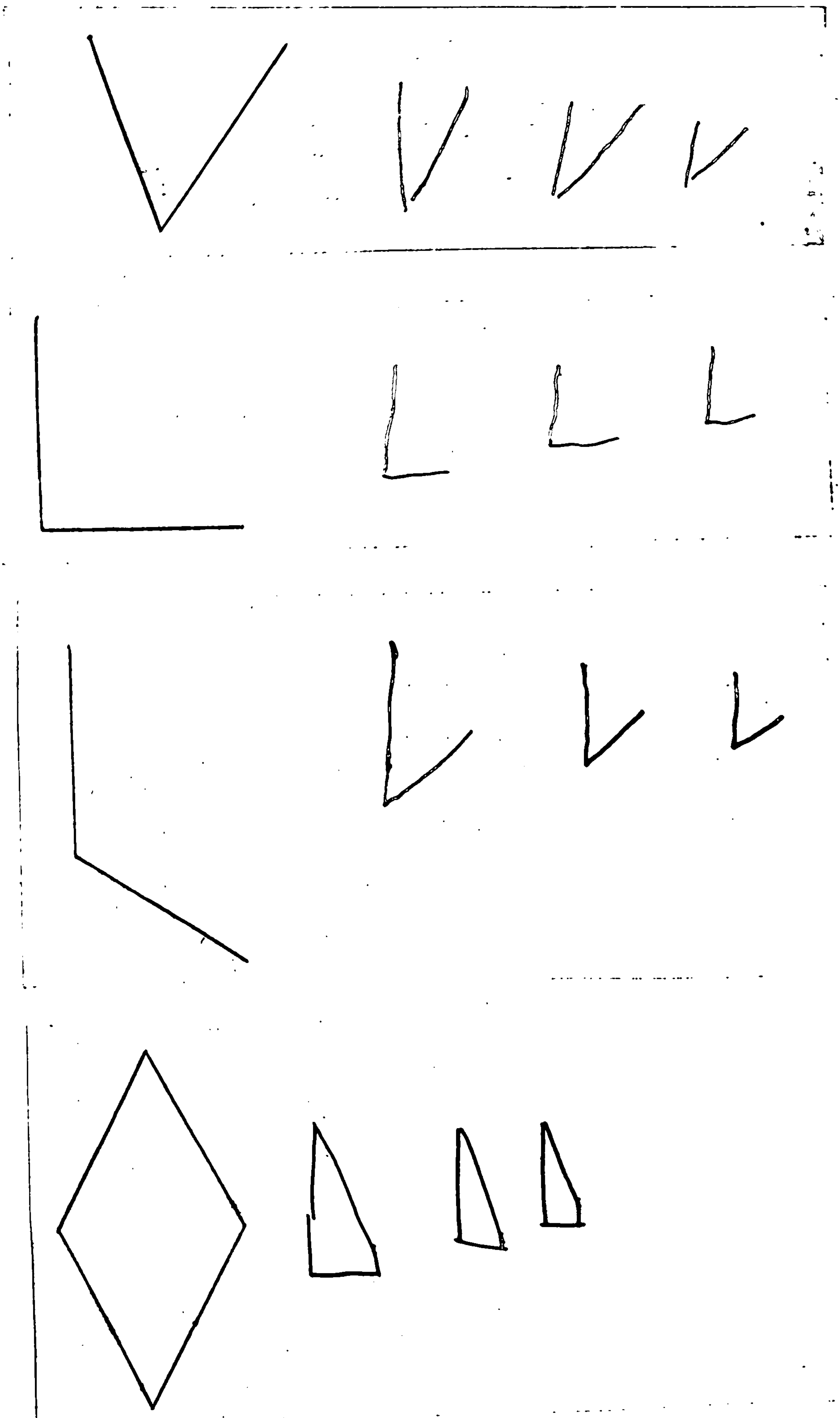

Figure 8. Examples showing tendency to draw subsequent figures smaller.

In Figure 8 an illustration is given of the tendency to decrease the size of each of the subsequent drawings with four subjects drawing four various figures.

C. Verbal, Performance and Scholastic Attainments Tests.

In the course of the foregoing research it became apparent that the two groups of mental defectives, different primarily in their drawing ability and secondly in the S.R.T., Pressure and Performance Time tests, seem to differ also in verbal and practical tests and in the simple scholastic attainments such as an ability to read and write. It has been decided to compare the results of the practical and verbal tests obtained previously with both groups. The scholastic attainments of those two groups were assessed by means of a very simple test. The verbal test employed by the writer was the Revised Stanford-Binet Intelligence Scale, Form L. The I.Q's obtained with both groups are given in the table below. The practical test used was the Alexander Performance Scale. It is, however, impossible to give the results of this test in the form of P.A.R.'s (Practical Ability Ratio) for the whole of the subjects as only 13 subjects were testable by this test in Group I and 54 in Group II. Any statistical comparison between the P.A.R.'s obtained with both Groups seem to be difficult and conclusions drawn from it only approximate. Because of this, it was decided to use the raw score obtained by each subject in the practical test, irrespective of whether his P.A.R. could be calculated from it or not. Results of the practical test recorded in the form of raw scores are liable to interpretation by the use of simple statistical methods. It should be mentioned that in order to obtain P.A.R. every female subject has to score at least 51, and each male subject at least 58 on the three sub-tests of which the Alexander test is composed. In the table below are given I.Q's obtained by each subject on a verbal test, and the raw score on a practical test. "x" denotes those subjects whose raw scores could be changed into P.A.R.'s, "-" denotes those subjects whose raw scores were below testable limit.

Results of the verbal and practical tests obtained with Group I (mental defective subjects, who were unable to draw an obtuse angle).

Nr. of subject	I.Q. Rev. Stanford-Binet Intelligence Scale, F.L.	Alexander Performance Scale Raw Score	x testable - untestable
1	44	79	x
2	46	18	-
3	41	14	-
4	44	108	x
5	47	20	-
6	43	18	-
7	39	20	-
8	47	49	-
9	44	19	-
10	44	48	-
11	47	23	-
12	40	28	-
13	38	44	-
14	43	20	-
15	38	45	-
16	46	58	x
17	44	73	x
18	41	54	-
19	43	4	-
20	39	10	-
21	49	83	x
22	39	8	-
23	40	60	x
24	44	10	-
25	47	83	x
26	42	20	-
27	42	25	-
28	38	30	-
29	42	50	-
30	48	54	-
31	46	18	-
32	45	20	-
33	39	16	-
34	49	105	x
35	41	18	-
36	43	89	x
37	42	38	-
38	41	17	-
39	41	16	-
40	49	30	-
41	48	24	-
42	38	4	-
43	42	17	-
44	43	87	x
45	41	25	-
46	42	30	-
47	42	19	-
48	44	36	-
49	42	78	x
50	41	15	-
51	41	12	-
52	46	17	-
53	43	15	-
54	38	23	-
55	41	17	-
56	39	67	x
57	46	59	x
58	41	20	-
59	41	14	-
60	39	20	-

Results of the verbal and performance tests obtained with Group II.

(Mentally defective subjects who were able to draw an obtuse angle).

Nr. of subject	I.Q. Rev. Stanford-Binet Intelligence Scale. F.L.	Alexander Performance Scale. Raw Score	x testable - untestable
1	43	137	x
2	49	67	x
3	46	93	x
4	39	25	-
5	49	80	x
6	56	44	-
7	50	126	x
8	52	61	x
9	49	48	-
10	48	109	x
11	48	112	x
12	51	67	x
13	51	128	x
14	51	99	x
15	48	93	x
16	57	37	-
17	46	120	x
18	44	93	x
19	50	95	x
20	54	58	x
21	56	155	x
22	53	99	x
23	50	142	x
24	47	118	x
25	48	60	x
26	43	59	x
27	39	65	x
28	51	99	x
29	49	65	x
30	56	136	x
31	57	124	x
32	56	125	x
33	48	155	x
34	48	102	x
35	50	100	x
36	41	63	x
37	54	103	x
38	49	90	x
39	56	108	x
40	51	117	x
41	42	52	-
42	47	127	x
43	51	132	x
44	51	87	x
45	57	143	x
46	47	111	x
47	48	40	-
48	48	66	x
49	49	111	x
50	56	103	x
51	42	14	-
52	46	78	x
53	44	93	x
54	56	108	x
55	54	120	x
56	42	74	x
57	49	68	x
58	52	111	x
59	51	102	x
60	54	89	x

Results of the scholastic attainments test.

		Group I	Group II
Number of subjects		60	60
Reading	Can read text	1	24
	Can read simple words and short sentences.	6	7
	Can read single separate words.	6	4
	Can recognize letters	3	2
	Cannot even recognize letters	44	23
Writing	Can write	0	26
	Can write name only	8	10
	Can print name only	22	17
	Can print some letters	3	0
	Cannot even print letters	27	7

Summary.

In this chapter methods of selection of the three groups participating in the main experiment, instruments used and procedures applied are described. The results of the Pressure, Performance Time, Drawing, Verbal and Performance tests and also the Simple Scholastic Attainments test obtained from two groups composed of mentally defective subjects are given. Only the results of the Pressure and Performance Time tests are given in the case of the third group composed of nursing staff, as it was assumed that all subjects in this group could read, write and draw simple geometrical figures.

CHAPTER VI.

STATISTICAL INTERPRETATION OF THE RESULTS OBTAINED.

The purpose of the present chapter is two-fold:
(a) to see whether the difference between the means of various tests, obtained with three different groups of subjects, is statistically significant, and
(b) to find out whether there is any correlation between the results of various tests within the same group.

The differences between the means for the Simple Reaction Time and Pressure and Performance Time tests were investigated firstly, between the two groups consisting of mental defectives and secondly, between the higher grade group of mental defectives and the group made up of nursing staff.

It was only possible to investigate the difference between the means for verbal and practical tests between the two groups composed of mentally defective subjects, as these tests were only carried out with these two groups.

The results of other tests obtained with two groups of mental defectives, as for example the drawing of various angles and a diamond, the ability to improve drawing by practice, the tendency for each successive drawing to decrease in size and scholastic attainments tests were not investigated statistically, but these results differ so strikingly in both groups, that the statistical evaluation of them would appear to be superfluous. The ability of the normal group to draw, read and write was not investigated since the results of nurses examinations gave no cause for doubt in this matter.

The significant difference between the means of various tests was calculated by the usual statistical method. Correlation between the results of various tests was calculated by r (product-moment correlation). Applying the null hypothesis, a correlation (r) of up to 0.253 may occur 5 times in 100 or r of up to 0.332 once in 100 from errors and fluctuations of sampling when N is 60. Clearly any value of r which falls between 0.253 and 0.332 is significant at 5% level, and r of 0.333 and over at 1% level of confidence for N=60.

Some of the items such as the standard deviation and the mean, which are necessary for the calculation of r, were taken from the first part of this chapter dealing with the calculation of the significant difference between various means. In one instance, when calculating r between various tests within the group composed of nursing staff, it was necessary to calculate the standard deviation and the mean anew, because of a difference in the number of subjects of this group taking part in the S.R.T. experiment (70 subjects), and in the Pressure and Performance Time experiment (60 subjects). For the purpose of calculating the correlation between different variables, the results of ten subjects were eliminated from the record list giving the results of the S.R.T. test of staff. The elimination was carried out in the following way: the five best and the five worst results of the S.R.T. were omitted from the original list given in Chapter IV and subsequently because of the change in number of subjects, all other items had to be calculated anew.

There is another point which it seems necessary to explain, i.e. the approximation to 1/3 of a second accepted in the Performance Time test. This was chiefly determined by the limitation of the Electric Time Clock which was recording performance time below pressure curves in the form of dashes corresponding to 2/3 and 1/3 of a second. If the vertical line drawn from the end of the pressure-curve cut off half or more than half of the dash representing 1/3 of a second, then 1/3 of a second was added to the performance time. If it cut off less than half of the dash, then nothing was added. As

540 trials were carried out altogether, the total result of the performance time for each group should not be greatly affected by this approximation. Moreover, possible errors made by adding or subtracting 1/3 of a second seem to be proportionally negligible as the time to draw each angle lasted usually several seconds.

Difference between means.

Group I

Nr of subject	X (Simple Reaction Time) in milliseconds	X^2
1	407	165649
2	366	133956
3	952	906304
4	283	80089
5	301	90601
6	399	159201
7	303	91809
8	250	62500
9	537	288369
10	271	73441
11	299	89401
12	362	131044
13	372	138384
14	302	91204
15	474	224676
16	291	84681
17	563	316969
18	342	116964
19	359	128881
20	394	155236
21	515	265225
22	327	106929
23	452	204304
24	307	94249
25	491	241081
26	333	110889
27	347	120409
28	711	505521
29	594	352836
30	609	370881
31	387	149769
32	628	394384
33	642	412164
34	518	268324
35	452	204304
36	316	99856
37	682	465124
38	342	116964
39	300	90000
40	546	298116

Difference between means.

Group I

continuation.

Nr of subject	X (Simple Reaction Time) in milliseconds	X^2
41	297	88209
42	412	169744
43	273	74529
44	520	270400
45	567	321489
46	486	236196
47	383	146689
48	392	153664
49	312	97344
50	323	104329
51	316	99856
52	517	267289
53	364	132496
54	358	128164
55	666	443556
56	575	330625
57	459	210681
58	512	262144
59	367	134689
60	365	133225
N = 60	S(X) = 25795	$S(X^2)$ = 12206006

$$\text{Mean} = \bar{X} = \frac{S(x)}{N} = \frac{25795}{60} = 429.9166$$

$$\text{Variance} = \mu = \sigma^2 = \frac{S(X^2)}{N} - \bar{X}^2 = \frac{12206006}{60} - (429.9166)^2 =$$

$$= 19705.1504.$$

Difference between means.

Group II.

Nr of subject	X (Simple Reaction Time) in milliseconds	X^2
1	195	38025
2	259	67081
3	250	62500
4	231	53361
5	232	53824
6	199	39601
7	240	57600
8	293	85849
9	172	29584
10	238	56644
11	252	63504
12	214	45796
13	194	37636
14	272	73984
15	214	45796
16	276	76176
17	279	77841
18	288	82944
19	254	64516
20	226	51076
21	250	62500
22	331	109561
23	230	52900
24	311	96721
25	307	94249
26	237	56169
27	304	92416
28	169	28561
29	308	94864
30	207	42849
31	257	66049
32	293	85849
33	258	66564
34	290	84100
35	225	50625
36	191	36481
37	205	42025
38	274	75076
39	192	36864
40	354	125316

Difference between means.

Group II

continuation.

Nr of subject	X (Simple Reaction Time) in milliseconds	X^2
41	178	31684
42	209	43681
43	174	30276
44	266	70756
45	235	55225
46	286	81796
47	210	44100
48	272	73984
49	194	27636
50	165	27225
51	241	58081
52	265	70225
53	182	33124
54	213	45369
55	213	45369
56	289	83521
57	278	77284
58	176	30976
59	295	87025
60	228	51984
N = 60	S(X) = 14550	$S(X^2)$=3642395

Mean $= \bar{X} = \frac{S(X)}{N} = \frac{14550}{60} = 242.5;$

Variance $= \mu = \sigma^2 = \frac{S(X^2)}{N} - \bar{X}^2 = \frac{3642395}{60} - (242.5)^2 = 1850.3333;$

Difference between means (Group I and Group II) =

$= \bar{X}_1 - \bar{X}_2 = 429.9166 - 242.5 = 187.4166;$

Standard error of difference $= \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} = \sqrt{\frac{19705.1504 + 1850.3333}{60}} =$

$= \sqrt{359.258} = 18.947;$

Critical ratio $= \frac{\bar{X}_1 - \bar{X}_2}{\text{S. e. of diff}} = \frac{187.4166}{18.947} = 9.8916$ Sig. at 1% level.

Difference between means.

Group of nursing staff.

Nr. of subject	X (Simple Reaction Time) in milliseconds	X^2
1	147	21609
2	182	33124
3	197	38809
4	212	44944
5	167	27889
6	180	32400
7	171	29241
8	144	20736
9	184	33856
10	142	20164
11	159	25281
12	191	36481
13	169	28561
14	177	31329
15	178	31684
16	167	27889
17	197	38809
18	180	32400
19	149	22201
20	163	26569
21	165	27225
22	181	32761
23	218	47524
24	254	64516
25	172	29584
26	184	33856
27	160	25600
28	170	28900
29	167	27889
30	156	24336
31	164	26896
32	182	33124
33	134	17956
34	155	24025
35	232	53824
36	188	35344
37	190	36100
38	214	45796
39	210	44100
40	195	38025
41	218	47524
42	165	27225
43	191	36381
44	215	46225
45	171	29241

Difference between means.

Group of nursing staff.

continuation.

Nr of subject	X (Simple Reaction Time) in milliseconds	X^2
46	203	41209
47	154	23716
48	183	33489
49	189	35721
50	176	30976
51	217	47089
52	184	33856
53	190	36100
54	198	39204
55	249	62001
56	200	40000
57	168	28224
58	203	41209
59	224	50176
60	156	24336
61	183	33489
62	128	16384
63	181	32761
64	181	32761
65	204	41616
66	175	30625
67	149	22201
68	199	39601
69	175	30625
70	165	27225
N = 70	S(X) = 12731	$S(X^2)$ = 2361637

Mean $= \bar{X}^2 = \frac{S(x)}{N} = \frac{12731}{70} = 181.8714;$

Variance $= \mu = \sigma^2 = \frac{S(x^2)}{N} - \bar{x}^2 = \frac{2361637}{70} - (181.8714)^2 = 660.4651;$

Difference between means (Group II and Group of nursing staff) $= \bar{X}_1 - \bar{X}_2 = 242.5 - 181.8714 = 60.6286;$

Standard error of difference $= \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} = \sqrt{\frac{660.4651}{70} + \frac{1850.3333}{60}} =$

$= \sqrt{40.274} = 6.346;$

Critical ratio $= \frac{\bar{X}_1 - \bar{X}_2}{S.e. \text{ of diff.}} = \frac{60.6286}{6.346} = 9.5538$ Sig. at 1% level.

Difference between means.

Group I

Nr of subject	X (Sum of pressures for the three angles) in square inches.	X^2
1	16 17	261 4689
2	6 67	44 4889
3	9 09	82 6281
4	13 88	192 6544
5	17 02	289 6804
6	10 45	109 2025
7	7 05	49 7025
8	4 74	22 4676
9	22 29	496 8441
10	9 14	83 5396
11	9 68	93 7024
12	23 13	534 9969
13	28 26	798 6276
14	29 32	859 6624
15	19 88	395 2144
16	11 32	128 1424
17	12 29	151 0441
18	10 24	104 8576
19	9 56	91 3936
20	22 53	507 6009
21	10 27	105 4729
22	15 04	226 2016
23	24 72	611 0784
24	9 70	94 0900
25	17 35	301 0225
26	20 73	429 7329
27	8 99	80 8201
28	22 54	508 0516
29	20 86	435 1396
30	39 08	1527 2464
31	14 72	216 6784
32	15 37	263 2369
33	10 75	115 5625
34	9 71	94 2841
35	32 55	1059 5025
36	12 68	160 7824
37	6 40	40 9600
38	22 96	527 1616
39	6 72	45 1584
40	20 40	416 1600

Difference between means.

Group I.

continuation.

Nr of subject	X (Sum of pressures for the three angles) in square inches.	X^2
41	30 00	900 0000
42	19 20	368 6400
43	16 41	269 2881
44	13 63	185 7769
45	13 16	173 1856
46	7 42	55 0564
47	22 45	504 0025
48	16 13	260 1769
49	11 41	130 1881
50	10 91	119 0281
51	5 66	32 0356
52	7 59	57 6081
53	9 40	88 3600
54	51 62	2664 6244
55	12 53	157 0009
56	8 41	70 7281
57	11 64	135 4896
58	13 42	180 0964
59	8 12	65 9344
60	21 95	481 8025
N = 60	S(X) = 945.31	$S(X^2)$ = 19428.2847

$$\text{Mean}\ \frac{S(X)}{N} = \frac{945\ 31}{60} = 15.7551$$

$$\text{Variance} = \mu = \sigma^2 = \frac{S(X^2)}{N} - \bar{X}^2 = \frac{19428\ 2847}{60} - \bar{X}^2 = 75.5816$$

Difference between means.

Group II

Nr of subjects	X (Sum of pressures for the three angles) in square inches.	X^2
1	1 83	3 3489
2	5 97	35 6409
3	9 71	94 2841
4	1 08	1 1664
5	8 01	64 1601
6	3 84	14 7456
7	2 18	4 7524
8	13 05	170 3025
9	3 63	13 1769
10	7 04	49 5616
11	4 96	24 6016
12	2 63	6 9169
13	3 20	10 2400
14	2 35	5 5225
15	3 04	9 2416
16	2 47	6 1009
17	2 82	7 9524
18	4 84	23 3289
19	3 39	11 4921
20	8 39	70 3921
21	1 28	1 6384
22	7 40	54 7600
23	7 61	57 9121
24	10 01	100 2001
25	9 18	84 2724
26	6 81	46 3761
27	2 28	5 1984
28	4 12	16 9744
29	6 49	42 1201
30	2 27	5 1529
31	3 76	14 1376
32	3 74	13 9876
33	3 04	9 2416
34	2 17	4 7089
35	4 56	20 7936
36	1 00	1 0000
37	5 05	25 5025
38	3 27	10 6929
39	1 98	3 9204
40	0 60	0 3600

Difference between means.

Group II

continuation,

Nr of subject	X (Sum of pressures for the three angles) in square inches.	X^2
41	8 19	67 0761
42	2 71	7 3441
43	2 97	8 8209
44	1 30	1 6900
45	8 71	75 8641
46	2 46	6 0516
47	1 17	1 3689
48	4 98	24 8004
49	2 35	5 5225
50	1 50	2 2500
51	2 51	6 3001
52	4 09	16 7281
53	6 24	38 9376
54	1 31	1 7161
55	10 75	115 5625
56	3 07	9 4249
57	3 20	10 2400
58	2 36	5 5696
59	10 38	107 7444
60	3 35	11 2225
N = 60	S(X) = 264.64	$S(X^2)$ = 1670.1128

$$\text{Mean} = \bar{X} = \frac{S(X)}{N} = \frac{264.64}{60} = 4.4106$$

$$\text{Variance} = \mu_2 = \sigma^2 = \frac{S(X^2)}{N} - \bar{X}^2 = \frac{1670.1128}{60} - \bar{X}^2 = 8.3819$$

Difference between means (Group I and Group II) =

$$= \bar{X}_2 - \bar{X}_1 = 15.7551 - 4.4106 = 11.3445;$$

Standard error of difference $= \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} = \sqrt{\frac{75.5816 + 8.3819}{60}} =$

$$= \sqrt{1.3993} = 1.1829;$$

Critical ratio $= \frac{\bar{X}_2 - \bar{X}_1}{S.e. of diff} = \frac{11.3445}{1.1829} = 9.5904$ Sig. at 1 % level.

Difference between means.

Group of nursing staff.

Nr of subject	X (Sum of pressures for the three angles) in square inches.	X^2
1	3 59	12 8881
2	3 45	11 9025
3	1 14	1 2996
4	1 25	1 5625
5	1 61	2 5921
6	1 12	1 2544
7	0 91	0 8281
8	7 82	61 1524
9	1 75	3 0625
10	5 03	25 3009
11	3 25	10 5625
12	7 73	59 7529
13	1 28	1 6384
14	1 77	3 1329
15	3 17	10 0489
16	1 52	2 3104
17	2 09	4 3681
18	2 65	7 0225
19	4 63	21 4369
20	3 32	11 0224
21	2 90	8 4100
22	6 08	36 9664
23	6 93	48 0249
24	1 25	1 5625
25	3 17	10 0489
26	3 18	10 1124
27	7 12	50 6944
28	0 82	0 6724
29	2 89	8 3521
30	3 63	13 1769
31	1 85	3 4225
32	4 03	16 2409
33	2 98	8 8804
34	1 67	2 7889
35	1 16	1 3456
36	1 55	2 4025
37	5 47	29 9209
38	1 03	1 0609
39	8 03	64 4809
40	5 71	32 6041

Difference between means

Group of nursing staff.

continuation.

Nr of subject	X (Sum of pressures for the three angles) in square inches	X^2
41	2 33	5 4289
42	2 12	4 4944
43	4 01	16 0801
44	3 51	12 3201
45	0 66	0 4356
46	0 60	0 3600
47	4 76	22 6576
48	4 64	21 5296
49	6 28	39 4384
50	2 27	5 1529
51	2 11	4 4521
52	4 21	17 7241
53	3 01	9 0601
54	2 31	5 3361
55	1 39	1 9321
56	0 43	0 1849
57	2 89	8 3521
58	9 57	91 5849
59	0 51	0 2601
60	2 83	8 0089
N=60	S(X)=190.97	$S(X^2)$ = 879.1005

$$\text{Mean} = \bar{X} = \frac{S(X)}{N} = \frac{190.97}{60} = 3.1828$$

$$\text{Variance} = \mu = \sigma^2 = \frac{S(X^2)}{N} - \bar{X}^2 = \frac{879.1005}{60} - \bar{X}^2 = 4.5214$$

Difference between means (Group II and Group of nursing staff) =

$$= \bar{X}_2 - \bar{X}_1 = 4.4106 - 3.1828 = 1.2278;$$

$$\text{Standard error of difference} = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} = \sqrt{\frac{8.3819 + 4.5214}{60}} =$$

$$= \sqrt{0.215} = 0.4638;$$

$$\text{Critical ratio} = \frac{\bar{X}_2 - \bar{X}_1}{\text{S.e. of diff.}} = \frac{1.2278}{0.4638} = \frac{1.2278}{0.4638} = 2.6472$$ Sig at 1% level.

Difference between means.

Group I

Nr of subject	X (Sum of performance times for the three angles) to the nearest 1/3 of sec.	X^2
1	28 33	802 5889
2	29 66	879 7156
3	29 00	841 0000
4	25 33	641 6089
5	22 33	498 6289
6	22 66	513 4756
7	27 66	765 0756
8	25 33	641 6089
9	47 33	2240 1289
10	36 66	1343 9556
11	43 00	1849 0000
12	40 33	1626 5089
13	46 33	2146 4689
14	39 66	1572 9156
15	25 33	641 6089
16	41 00	1681 0000
17	22 66	513 4756
18	23 33	544 2889
19	21 66	469 1556
20	28 66	821 3956
21	24 00	576 0000
22	29 00	841 0000
23	23 33	544 2889
24	24 00	576 0000
25	36 66	1319 8689
26	58 00	3364 0000
27	20 33	413 3089
28	32 33	1045 2289
29	38 00	1444 0000
30	47 66	2271 4756
31	29 00	841 0000
32	26 00	676 0000
33	20 66	426 8356
34	21 66	469 1556
35	42 66	1819 8756
36	22 66	513 4756
37	14 33	205 3489
38	30 00	900 0000
39	26 00	676 0000
40	25 66	658 4356

Difference between means.

Group I.

continuation.

Nr of subject	X (Sum of performance times for the three angles) to the nearest 1/3 of sec.	X^2
41	35 33	1246 2089
42	24 66	608 1156
43	30 00	900 0000
44	26 33	693 2689
45	23 66	559 7956
46	17 00	289 0000
47	28 00	784 0000
48	34 33	1178,5489
49	37 66	1418 2756
50	26 00	676 0000
51	18 33	335 9889
52	17 00	289 0000
53	20 33	413 3089
54	31 00	961 0000
55	17 66	311 8756
56	15 66	245 2356
57	19 33	373 6489
58	30 66	940 0356
59	23 33	544 2889
60	40 33	1626 5089
N = 60	S(X) = 1735.00	$S(X^2)$ = 55011.0078

$$\text{Mean} = \bar{X} = \frac{S(X)}{N} = \frac{1735}{60} = 28.9166$$

$$\text{Variance} = \mu = \sigma^2 = \frac{S(X^2)}{N} - \bar{x}^2 = \frac{55011.0078}{60} - \bar{x}^2 = 80.6804$$

Difference between means.

Group II

Nr of subject	X (Sum of performance times for the three angles) to the nearest 1/3 of sec.	X^2
1	14 66	214 9156
2	22 00	484 0000
3	20 66	426 8356
4	25 66	658 4356
5	24 66	608 1156
6	13 00	169 0000
7	27 00	729 0000
8	30 33	919 9089
9	33 33	1110 8889
10	33 00	1089 0000
11	21 33	454 9689
12	31 33	981 5689
13	13 66	186 5956
14	18 66	348 1956
15	17 00	289 0000
16	13 33	177 6889
17	16 66	277 5556
18	19 00	361 0000
19	13 33	177 6889
20	22 33	498 6289
21	26 00	676 0000
22	21 00	441 0000
23	16 00	256 0000
24	19 00	361 0000
25	20 00	400 0000
26	18 33	335 9889
27	19 66	386 5156
28	17 66	311 8756
29	22 00	484 0000
30	12 00	144 0000
31	13 00	169 0000
32	18 33	335 9889
33	8 66	74 9956
34	21 66	469 1556
35	13 66	186 5956
36	11 33	128 3689
37	15 66	245 2356
38	15 66	245 2356
39	11 66	135 9556
40	8 66	74 9956

Difference between means,

Group II

continuation.

Nr of subject	X (Sum of performance times for the three angles) to the nearest 1/3 of sec.	X^2
41	19 66	386 5156
42	22 00	484 0000
43	18 66	348 1956
44	42 33	1791 8289
45	16 00	256 0000
46	11 00	121 0000
47	13 00	169 0000
48	21 33	454 9689
49	10 66	113 6356
50	9 00	81 0000
51	14 33	205 3489
52	17 33	300 3289
53	17 00	289 0000
54	14 00	196 0000
55	28 33	802 5889
56	21 66	469 1556
57	10 00	100 0000
58	9 33	87 0489
59	24 66	608 1156
60	14 00	196 0000
N = 60	S(X) = 1115.33	$S(X^2)$ = 23484.6300

$$\text{Mean} = \bar{X} = \frac{S(X)}{N} = \frac{1115.33}{60} = 18.5888$$

$$\text{Variance} = \mu = \sigma^2 = \frac{S(X^2)}{N} - \bar{X}^2 = \frac{23484.63}{60} - \bar{X}^2 = 47.3837$$

Difference between means (Group I and Group II) =

$\bar{X}_2 - \bar{X}_1 = 28.9166 - 18.5888 = 10.3278$;

Standard error of difference $= \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} = \sqrt{\frac{80.6804 + 47.3837}{60}} =$

$= \sqrt{2.1344} = 1.461$;

Critical ratio $= \frac{\bar{X}_2 - \bar{X}_1}{\text{S.e. of diff.}} = \frac{10.3278}{1.461} = 7.0689$ Sig. at 1% level.

Difference between means,

Group of Nursing staff.

Nr of subject	X (Sum of performance times for the three angles) to the nearest 1/3 of sec.	X^2
1	18 66	348 1956
2	12 00	144 0000
3	9 00	81 0000
4	10 66	113 6356
5	7 66	58 6756
6	11 66	135 9556
7	6 66	44 3556
8	18 00	324 0000
9	5 00	25 0000
10	14 00	196 0000
11	16 33	266 6689
12	7 66	58 6756
13	9 33	87 0489
14	8 00	64 0000
15	9 33	87 0489
16	9 66	93 3156
17	21 33	454 9689
18	15 66	245 2356
19	28 66	821 3956
20	13 66	186 5956
21	7 66	58 6756
22	27 66	765 0756
23	17 33	300 3289
24	7 66	58 6756
25	7 00	49 0000
26	8 66	74 9956
27	14 00	196 0000
28	9 66	93 3156
29	3 66	13 3956
30	5 66	32 0356
31	8 66	74 9956
32	7 33	53 7389
33	10 00	100 0000
34	8 33	69 3889
35	10 33	106 7089
36	4 66	21 7156
37	9 66	93 3156
38	11 00	121 0000
39	12 33	152 0289
40	15 33	235 0089

Difference between means.

Group of nursing staff.

continuation.

Nr of subject	X (Sum of performance times for the three angles) to the nearest 1/3 of sec.	X^2
41	6 66	44 3556
42	11 33	128 3689
43	10 33	106 7089
44	10 00	100 0000
45	8 33	69 3889
46	5 66	32 0356
47	16 66	277 5556
48	16 33	266 6689
49	14 33	205 3489
50	20 00	400 0000
51	8 33	69 3889
52	13 00	169 0000
53	21 33	454 9889
54	12 66	160 2756
55	13 33	177 6889
56	4 66	21 7156
57	8 33	69 3889
58	22 00	484 0000
59	7 00	49 0000
60	8 33	69 3889
N = 60	S(X) = 698.33	$S(X^2)$=9860.4080

$$\text{Mean} = \bar{X} = \frac{S(X)}{N} = \frac{698.33}{60} = 11.6388$$

$$\text{Variance} = \mu = \sigma^2 = \frac{S(X^2)}{N} - \bar{X}^2 = \frac{9860.4080}{60} - \bar{X}^2 = 28.8785$$

Difference between means (Group II and Group of nursing staff) =

$= \bar{X}_2 - \bar{X}_1 = 18.5888 - 11.6388 = 6.95;$

Standard error of difference $= \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} = \sqrt{\frac{28.8785 + 47.3837}{60}} =$

$= \sqrt{1.271} = 1.127;$

Critical ratio $= \frac{\bar{X}_2 - \bar{X}_1}{S.e. of diff} = \frac{6.95}{1.127} = 6.1668$ Sig. at 1% level.

Difference between means.

Alexander Performance Scale.

Group I

Nr of subject	X Sum of raw score	X^2
1	79	6241
2	18	324
3	14	196
4	108	11664
5	20	400
6	18	324
7	20	400
8	49	2401
9	19	361
10	48	2304
11	23	529
12	28	784
13	44	1936
14	20	400
15	45	2025
16	58	3364
17	73	5329
18	54	2916
19	4	16
20	10	100
21	83	6889
22	8	64
23	60	3600
24	10	100
25	83	6889
26	20	400
27	25	625
28	30	900
29	50	2500
30	54	2916
31	18	324
32	20	400
33	16	256
34	105	11025
35	18	324
36	89	7921
37	38	1444
38	17	289
39	16	256
40	30	900

Difference between means.

Alexander Performance Scale.

Group I

continuation.

Nr of subject	X Sum of raw score	X^2
41	24	576
42	4	16
43	17	289
44	87	7569
45	25	625
46	30	900
47	19	361
48	36	1296
49	78	6084
50	15	225
51	12	144
52	17	289
53	15	225
54	23	529
55	17	289
56	67	4489
57	29	3481
58	20	400
59	14	196
60	20	400
N = 60	S(X)=2141	$S(X^2)$=118419

$$\text{Mean} = \bar{X} = \frac{S(X)}{N} = \frac{2141}{60} = 35.68$$

$$\text{Variance} = \mu = \sigma^2 = \frac{S(X^2)}{N} - \bar{X}^2 = \frac{119419}{60} - 1273.06 = 700.59$$

Difference between means.

Alexander Performance Scale.

Group II

Nr of subject	X Sum of raw score	X^2
1	137	18769
2	67	4489
3	93	8649
4	25	625
5	80	6400
6	44	1936
7	126	15876
8	61	3721
9	48	2304
10	109	11881
11	112	12544
12	67	4489
13	128	16384
14	99	9801
15	93	8649
16	37	1369
117	120	14400
18	93	8649
19	95	9025
20	58	3364
21	155	24025
22	99	9801
23	142	20164
24	118	13924
25	60	3600
26	59	3481
27	112	12544
28	99	9801
29	65	4225
30	136	18496
31	124	15376
32	125	15625
33	155	24025
34	102	10404
35	100	10000
36	63	3969
37	103	10609
38	90	8100
39	108	11664
40	117	13689

Difference between means.

Alexander Performance Scale.

Group II.

continuation.

Nr of subject	X Sum of raw score	X^2
41	52	2704
42	127	16129
43	132	17424
44	87	7569
45	143	20449
46	111	12321
47	40	1600
48	66	4356
49	111	12321
50	103	10609
51	14	196
52	78	6084
53	93	8649
54	108	11664
55	120	14400
56	74	5476
57	68	4624
58	111	12321
59	102	10404
60	89	7921
N = 60	S(X)=5652	$S(X^2)$ = 594067

$$\text{Mean} = \overline{X} = \frac{S(X)}{N} = \frac{5652}{60} = 94.2$$

$$\text{Variance} = \mu = \sigma^2 = \frac{S(X^2)}{N} - \overline{X}^2 = 9901.11 - 8873.64 = 1027.47$$

Difference between means (Group I and Group II) =

$$= \bar{X}_2 - \bar{X}_1 = 94.2 - 35.68 = 58.52;$$

$$\text{Standard error of difference} = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} = \sqrt{\frac{1027.47 + 700.59}{60}} =$$

$$= \sqrt{28.8} = 5.34;$$

$$\text{Critical ratio} = \frac{\bar{X}_2 - \bar{X}_1}{\text{S.e. of diff.}} = \frac{58.52}{5.34} = 10.95$$ Sig. at 1 % level.

Difference between means.

Revised Stanford-Binet Intelligence Scale, Form L.

Group I

X	f	fx	fx^2
38	5	190	7220
39	6	234	9126
40	2	80	3200
41	11	451	18491
42	8	336	14112
43	6	258	11094
44	7	308	13552
46	5	230	10580
47	4	188	8836
48	3	144	6912
49	3	147	7203
	N=S(f) = 60	$\Sigma(fx)$=2566	$\Sigma(fx^2)$=110326

Mean $= \bar{X} = \frac{\Sigma(fx)}{N} = \frac{2566}{60} = 42.76;$

Variance $= \mu = \sigma^2 = \frac{\Sigma(fx^2)}{N} - \left(\frac{\Sigma(fx)}{N}\right)^2 = 1838.76 - 1828.41 = 10.35;$

Group II

X	f	fx	fx^2
39	1	39	1521
41	1	41	1681
42	4	168	7056
43	2	86	3698
44	2	88	3872
46	3	138	6348
47	4	188	8836
48	7	336	16128
49	7	343	16807
50	4	200	10000
51	8	408	20808
52	2	104	5408
53	1	53	2809
54	4	216	11664
56	7	392	21952
57	3	171	9747
	N=S(f)=60	$\Sigma(fx)$=2971	$\Sigma(fx^2)$=148335

Mean $= \bar{X} = \frac{\Sigma(fx)}{N} = \frac{2971}{60} = 49.5;$

Variance $= \mu = \sigma^2 = \frac{\Sigma(fx^2)}{N} - \left(\frac{\Sigma(fx)}{N}\right)^2 = 2472.25 - 2450.25 = 22;$

Difference between means (Group I and Group II) =

$= \bar{X}_2 - \bar{X}_1 = 49.5 - 42.76 = 6.74;$

Standard error of difference $= \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} = \sqrt{\frac{22 + 10.35}{60}} =$

$= \sqrt{0.539} = 0.73;$

Critical ratio $= \frac{\bar{X}_2 - \bar{X}_1}{\text{S. e. of diff}} = \frac{6.74}{0.73} = 9.23$ Sig. at 1% level.

Correlation between performance time and pressure.

Group I.

Nr of subj,	X Sum of perfor. times	Y Sum of pressures.	XY
1	28 33	16 17	458 0961
2	29 66	6 67	197 8322
3	29 00	9 09	263 6100
4	25 33	13 88	351 5804
5	22 33	17 02	380 0566
6	22 66	10 45	236 7970
7	27 66	7 05	195 0030
8	25 33	4 74	120 0642
9	47 33	22 29	1054 9857
10	36 66	9 14	335 0724
11	43 00	9 68	416 2400
12	40 33	23 13	932 8329
13	46 33	28 26	1309 2858
14	39 66	29 32	1162 8312
15	25 33	19 88	503 5604
16	41 00	11 32	464 1200
17	22 66	12 29	278 4914
18	23 33	10 24	238 8992
19	21 66	9 56	207 0696
20	28 66	22 53	645 7098
21	24 00	10 27	246 4800
22	29 00	15 04	436 1600
23	23 33	24 72	576 7176
24	24 00	9 70	232 8000
25	36 66	17 35	636 0510
26	58 00	20 73	1202 3400
27	20 33	8 99	182 7667
28	32 33	22 54	728 7182
29	38 00	20 86	792 6800
30	47 66	39 08	1862 5528
31	29 00	14 72	426 8800
32	26 00	15 37	399 6200
33	20 66	10 75	222 0950
34	21 66	9 71	210 3186
35	42 66	32 55	1388 5830
36	22 66	12 68	287 3288
37	14 33	6 40	91 7120
38	30 00	22 96	688 8000
39	26 00	6 72	174 7200
40	25 66	20 40	523 4640

Correlation between performance time and pressure.

Group I

Continuation.

Nr of subj.	X Sum of perfor. times.	Y Sum of pressures	XY
41	35 33	30 00	1059 9000
42	24 66	19 20	473 4720
43	30 00	16 41	492 3000
44	26 33	13 63	358 8779
45	23 66	13 16	311 3656
46	17 00	7 42	126 1400
47	28 00	22 45	628 6000
48	34 33	16 13	553 7429
49	37 66	11 41	429 7006
50	26 00	10 91	283 6600
51	18 33	5 66	103 7478
52	17 00	7 59	129 0300
53	20 33	9 40	191 1020
54	31 00	51 62	1600 2200
55	17 66	12 53	221 2798
56	15 66	8 41	131 7006
57	19 33	11 64	225 0012
58	30 66	13 42	411 4572
59	23 33	8 12	189 4396
60	40 33	21 95	889 2765
N = 60			S(XY)=29872.9393

Product moment correlation $= r = \dfrac{\frac{S(xy)}{N} - \bar{x}\bar{y}}{\sigma_x \sigma_y}$

$S(xy) = 29872.9393$

$N = 60$

$\bar{x} = 28.9166$

$\bar{y} = 15.7551$

$\sigma_x^2 = 80.6804$

$\sigma_y^2 = 75.5816$

$$r = \frac{\frac{29872.9393}{60} - 28.9166 \times 15.7551}{\sqrt{80.6804 \times 75.5816}} =$$

$$= \frac{42.2984}{78.09} = 0.541$$ Sig. at 1 % level.

Correlation between performance time and pressure.

Group II.

Nr of subj.	X Sum of perfor times.	Y Sum of pressures.	XY
1	14 66	1 83	26 8278
2	22 00	5 97	131 3400
3	20 66	9 71	200 6086
4	25 66	1 08	27 7128
5	24 66	8 01	197 5266
6	13 00	3 84	49 9200
7	27 00	2 18	58 8600
8	30 33	13 05	395 8065
9	33 33	3 63	120 9879
10	33 00	7 04	232 3200
11	21 33	4 96	105 7968
12	31 33	2 63	82 3979
13	13 66	3 20	43 7120
14	19 66	2 35	43 8510
15	17 00	3 04	51 6800
16	13 33	2 47	32 9251
17	16 66	2 82	46 9812
18	19 00	4 83	91 7700
19	13 33	3 39	45 1887
20	22 33	8 39	187 3487
21	26 00	1 28	33 2800
22	21 00	7 40	155 4000
23	16 00	7 61	121 7600
24	19 00	10 01	190 1900
25	20 00	9 18	183 6000
26	18 33	6 81	124 8273
27	19 66	2 28	44 8248
28	17 66	4 12	72 7592
29	22 00	6 49	142 7800
30	12 00	2 27	27 2400
31	13 00	3 76	48 8800
32	18 33	3 74	68 5542
33	8 66	3 04	26 3264
34	21 66	2 17	47 0022
35	13 66	4 56	62 2896
36	11 33	1 00	11 3300
37	15 66	5 05	79 0830
38	15 66	3 27	51 2082
39	11 66	1 98	23 0868
40	8 66	0 60	5 1960

Correlation between performance time and pressure.

Group II.

continuation.

Nr of subj.	X Sum of perfor times.	Y Sum of pressures	XY
41	19 66	8 19	161 0154
42	22 00	2 71	59 6200
43	18 66	2 97	55 4202
44	42 33	1 30	55 0290
45	16 00	8 71	139 3600
46	11 00	2 46	27 0600
47	13 00	1 17	15 2100
48	21 33	4 98	106 2234
49	10 66	2 35	25 0510
50	9 00	1 50	13 5000
51	14 33	2 51	35 9683
52	17 33	4 09	70 8797
53	17 00	6 24	106 0800
54	14 00	1 31	18 3400
55	28 33	10 75	304 5475
56	21 66	3 07	66 4962
57	10 00	3 20	32 0000
58	9 33	2 36	22 0188
59	24 66	10 38	255 9708
60	14 00	3 35	46 9000

N = 60 S(XY)=5319.8696

Product moment correlation = $r = \dfrac{\frac{S(xy)}{N} - \bar{x}\bar{y}}{\sigma_x \sigma_y}$

$S(xy) = 5319.8696$

$N = 60$

$\bar{x} = 18.5888$

$\bar{y} = 4.4106$

$\sigma_x^2 = 47.3837$

$\sigma_y^2 = 8.3819$

$$r = \frac{\frac{5319.8696}{60} - 18.5888 \times 4.4106}{\sqrt{47.3837 \times 8.3819}} =$$

$$= \frac{6.6767}{19.93} = 0.335 \cdot \text{Sig. at } 1\% \text{ level.}$$

Correlation between performance time and pressure.

Group of nursing staff.

Nr of subj.	X Sum of perfor times.	Y Sum of pressures	XY
1	18 66	3 59	66 9894
2	12 00	3 45	41 4000
3	9 00	1 14	10 2600
4	10 66	1 25	13 3250
5	7 66	1 61	12 3326
6	11 66	1 12	13 0592
7	6 66	0 91	6 0606
8	18 00	7 82	140 7600
9	5 00	1 75	8 7500
10	14 00	5 03	70 4200
11	16 33	3 25	53 0725
12	7 66	7 73	59 2118
13	9 33	1 28	11 9424
14	8 00	1 77	14 1600
15	9 33	3 17	29 5761
16	9 66	1 52	14 6832
17	21 33	2 09	44 5797
18	15 66	2 65	41 4990
19	28 66	4 63	132 6958
20	13 66	3 32	45 3512
21	7 66	2 90	22 2140
22	27 66	6 08	168 1728
23	17 33	6 93	120 0969
24	7 66	1 25	9 5750
25	7 00	3 17	22 1900
26	8 66	3 18	27 5388
27	14 00	7 12	99 6800
28	9 66	0 82	7 9212
29	3 66	2 89	10 5774
30	5 66	3 63	20 5458
31	8 66	1 85	16 0210
32	7 33	4 03	29 5399
33	10 00	2 98	29 8000
34	8 33	1 67	13 9111
35	10 33	1 16	11 9828
36	4 66	1 55	7 2230
37	9 66	5 47	52 8402
38	11 00	1 03	11 3300
39	12 33	8 03	99 0099
40	15 33	5 71	87 5343

Correlation between performance time and pressure.

Group of nursing staff.

continuation.

Nr of subj.	X Sum of perfor times.	Y Sum of pressures	XY
41	6 66	2 33	15 5178
42	11 33	2 12	24 0196
43	10 33	4 01	41 4233
44	10 00	3 51	35 1000
45	8 33	0 66	5 4968
46	5 66	0 60	3 3960
47	16 66	4 76	79 3016
48	16 33	4 64	75 7712
49	14 33	6 28	89 9924
50	20 00	2 27	45 4000
51	8 33	2 11	17 5763
52	13 00	4 21	54 7300
53	21 33	3 01	64 2033
54	12 66	2 31	29 2446
55	13 33	1 39	18 5287
56	4 66	0 43	2 0038
57	8 33	2 89	24 0737
58	22 00	9 57	210 5400
59	7 00	0 51	3 5700
60	8 33	2 83	23 5739

N = 60 S(XY) = 2561.2966

Product moment correlation = r = $\dfrac{\frac{S(xy)}{N} - \bar{x}\bar{y}}{\sigma_x \sigma_y}$

$S(xy) = 2561.2966$

$N = 60$

$\bar{x} = 11.6388$

$\bar{y} = 3.1828$

$\sigma_x^2 = 28.8785$

$\sigma_y^2 = 4.5214$

$$r = \frac{\frac{2561.2966}{60} - 11.6388 \times 3.1828}{\sqrt{28.8785 \times 4.5214}} =$$

$$= \frac{5.6443}{11.38} = 0.496$$ Sig. at 1 % level.

Correlation between Simple Reaction Time and Pressure.

Group I.

Nr of subj.	X S. R. T.	Y Sum of pressures	XY
1	407	16 17	6581 19
2	366	6 67	2441 22
3	952	9 09	8653 68
4	283	13 88	3928 04
5	301	17 02	5123 02
6	399	10 45	4169 55
7	303	7 05	2136 15
8	250	4 74	1185 00
9	537	22 29	11969 73
10	271	9 14	2476 94
11	299	9 68	2894 32
12	362	23 13	8373 06
13	372	28 26	10512 72
14	302	29 32	8854 64
15	474	19 88	9423 12
16	291	11 32	3294 12
17	563	12 29	6919 27
18	342	10 24	3502 08
19	359	9 56	3432 02
20	394	22 53	8876 82
21	515	10 04	5170 60
22	327	24 72	8083 44
23	609	15 04	9159 36
24	452	9 70	4384 40
25	307	17 35	5326 45
26	491	20 73	10178 43
27	333	8 99	2993 67
28	347	22 54	7821 38
29	711	20 86	14831 46
30	594	39 08	23213 52
31	387	14 72	5696 64
32	628	15 37	9652 36
33	642	10 75	6901 50
34	518	9 71	5029 78
35	452	32 55	14712 60
36	316	12 68	4006 88
37	682	6 40	4364 80
38	342	22 96	7852 32
39	300	6 72	2016 00
40	546	20 40	11138 40

Correlation between Simple Reaction Time and Pressure.

Group I.

continuation.

Nr of subj.	X S. R. T.	Y Sum of pressures.	XY
41	297	30 00	8910 00
42	412	19 20	7910 40
43	273	16 41	4479 93
44	520	13 63	7087 60
45	567	13 16	7461 72
46	486	7 42	3606 12
47	383	22 45	8598 35
48	392	16 13	6322 96
49	312	11 41	3559 92
50	323	10 91	3523 93
51	316	5 66	1788 56
52	517	7 59	3924 03
53	364	9 40	3421 60
54	358	51 62	18479 96
55	666	12 53	8344 98
56	575	8 41	4835 75
57	459	11 64	5342 76
58	512	13 42	6871 04
59	367	8 12	2980 04
60	365	21 95	8011 75

N = 60 S(XY)=402742.10

Product moment correlation = r = $\dfrac{\frac{S(xy)}{N} - \bar{x}\bar{y}}{\sigma_x \sigma_y}$

$S(xy) = 402742.10$

$N = 60$

$\bar{x} = 429.9166$

$\bar{y} = 15.7551$

$\sigma_x^2 = 19705.1504$

$\sigma_y^2 = 75.5816$

$$r = \frac{\frac{402742.10}{60} - 429.9166 \times 15.7551}{\sqrt{19705.1504 \times 75.5816}} =$$

$$= \frac{-61.0107}{385.9} = -0.158$$ Not Significant.

Correlation between Simple Reaction Time and Pressure.

Group II.

Nr of subj.	X S. R. T.	Y Sum of pressures.	XY
1	195	1 83	356 85
2	259	5 97	1546 23
3	250	9 71	2427 50
4	231	1 08	249 48
5	232	8 01	1858 32
6	199	3 84	764 16
7	240	2 18	523 20
8	293	13 05	3823 65
9	172	3 63	624 36
10	238	7 04	1675 52
11	252	4 96	1249 92
12	214	2 63	562 82
13	194	3 20	620 80
14	272	2 35	639 20
15	214	3 04	650 56
16	276	2 47	681 72
17	279	2 82	786 78
18	288	4 83	1391 04
19	254	3 39	861 06
20	226	8 39	1896 14
21	250	1 28	320 00
22	331	7 40	2449 40
23	230	7 61	1750 30
24	311	10 01	3113 11
25	307	9 18	2818 26
26	237	6 81	1613 97
27	304	2 28	693 12
28	169	4 12	696 28
29	308	6 49	1998 92
30	227	2 27	469 89
31	257	3 76	966 32
32	293	3 74	1095 82
33	258	3 04	784 32
34	290	2 17	629 30
35	225	4 54	1026 00
36	191	1 00	191 00
37	205	5 05	1035 25
38	274	3 27	895 98
39	192	1 98	380 16
40	354	0 60	212 40

Correlation between Simple Reaction Time and Pressure.

Group II.

continuation.

Nr of subj.	X S. R. T.	Y Sum of pressures.	XY
41	178	8 19	1457 82
42	209	2 71	566 39
43	174	2 97	516 78
44	266	1 30	345 80
45	235	8 71	2046 85
46	286	2 48	703 56
47	210	1 17	245 70
48	272	4 98	1354 56
49	194	2 35	455 90
50	165	1 50	247 50
51	241	2 51	604 91
52	265	4 09	1083 85
53	182	6 24	1135 68
54	213	1 31	279 03
55	213	10 75	2289 75
56	289	3 07	887 23
57	278	3 20	889 60
58	176	2 36	415 36
59	295	10 38	3062 10
60	228	3 35	763 80

N = 60 S(XY) = 65681.28

Product Moment correlation = r = $\dfrac{\dfrac{S(xy)}{N} - \bar{x}\bar{y}}{\sigma_x \sigma_y}$

$S(xy) = 65681.28$

$N = 60$

$\bar{x} = 242.5$

$\bar{y} = 4.4106$

$\sigma_x^2 = 1850.3333$

$\sigma_y^2 = 8.3819$

$$r = \frac{\dfrac{65681.28}{60} - 242.5 \times 4.4106}{\sqrt{1850.3333 \times 8.3819}} =$$

$$= \frac{25.1175}{124.53} = 0.2016$$ Not Significant.

Correlation between Simple Reaction Time and Pressure.

Group of nursing staff.

Nr of subj.	X S. R. T.	Y Sum of pressures	XY
1	147	3 59	527 73
2	182	3 45	627 90
3	197	1 14	224 58
4	212	1 25	265 25
5	167	1 61	268 87
6	180	1 12	201 60
7	171	0 91	155 61
8	144	7 82	1126 08
9	184	1 75	322 00
10	159	5 03	799 77
11	191	3 25	620 75
12	169	7 73	1306 37
13	177	1 28	226 56
14	178	1 77	315 06
15	167	3 17	529 39
16	197	1 52	299 44
17	180	2 09	376 20
18	149	2 65	394 85
19	163	4 63	754 69
20	165	3 32	547 80
21	181	2 90	524 90
22	172	6 08	1045 76
23	184	6 93	1275 12
24	160	1 25	200 00
25	170	3 17	538 90
26	167	3 18	531 06
27	156	7 12	1110 72
28	164	0 82	134 48
29	182	2 89	525 98
30	155	3 63	562 65
31	188	1 85	347 80
32	190	4 03	765 70
33	214	2 98	637 72
34	210	1 67	350 70
35	195	1 16	226 20
36	218	1 55	337 90
37	165	5 47	902 55
38	191	1 03	196 73
39	215	8 03	1726 45
40	171	5 71	976 41

Correlation between Simple Reaction Time and Pressure.

Group of nursing staff.

continuation.

Nr of subj.	X S. R. T.	Y Sum of pressures.	XY
41	203	2 33	472 99
42	183	2 12	387 96
43	189	4 01	757 89
44	176	3 51	617 76
45	217	0 66	143 22
46	184	0 60	110 40
47	190	4 76	904 40
48	198	4 64	918 72
49	200	6 28	1256 00
50	168	2 27	381 36
51	203	2 11	428 33
52	156	4 21	656 76
53	183	3 01	550 83
54	181	2 31	418 11
55	181	1 39	251 59
56	204	0 43	87 72
57	175	2 89	505 70
58	199	9 57	1904 43
59	175	0 51	89 25
60	165	2 83	466 95

N=60 S(XY)=34118.35

Product moment correlation $= r = \dfrac{\frac{S(xy)}{N} - \bar{x}\bar{y}}{\sigma_x \sigma_y}$

$S(xy) = 34118.35$

$N = 60$

$\bar{x} = 180.7833$

$\bar{y} = 3.1828$

$\sigma_x^2 = 370.3151$

$\sigma_y^2 = 4.5214$

$$r = \frac{\frac{34118.35}{60} - 180.7833 \times 3.1828}{\sqrt{370.3151 \times 4.5214}} =$$

$$= \frac{-6.7579}{40.91} = -0.165$$ Not Significant.

Correlation between Simple Reaction Time and Performance Time.

Group I

Nr of subj.	X S. R. T.	Y Sum of perfor. times.	XY
1	407	28 33	11530 31
2	366	29 66	10855 56
3	952	29 00	27608 00
4	283	25 33	7168 39
5	301	22 33	6721 33
6	399	22 66	9041 34
7	303	27 66	8380 98
8	250	25 33	6332 50
9	537	47 33	24016 21
10	271	36 66	9934 86
11	299	43 00	12857 00
12	362	40 33	14599 46
13	372	46 33	17234 76
14	302	39 66	11977 32
15	474	25 33	12006 42
16	291	41 00	11931 00
17	563	22 66	12757 48
18	342	23 33	7978 86
19	359	21 66	5609 94
20	394	28 66	11292 04
21	515	24 00	12360 00
22	327	29 00	9483 00
23	452	23 33	10545 16
24	307	24 00	7368 00
25	491	36 66	18000 06
26	333	58 00	19314 00
27	347	20 33	7054 51
28	711	32 33	22986 63
29	594	38 00	22572 00
30	609	47 66	28024 94
31	387	29 00	10623 00
32	628	26 00	16328 00
33	642	20 66	13263 72
34	518	21 66	11219 88
35	452	42 66	19282 32
36	316	22 66	7160 56
37	682	14 33	9783 06
38	342	30 00	10260 00
39	300	26 00	7800 00
40	546	25 66	14010 36

Correlation between Simple Reaction Time and Performance Time.

Group I

continuation.

Nr of subj.	X S. R. T.	Y Sum of perfor. times	XY
41	412	24 66	10159 92
42	297	35 33	10443 01
43	273	30 00	8190 00
44	520	26 33	13691 60
45	567	23 66	13415 22
46	486	17 00	8262 00
47	383	28 00	10694 00
48	392	34 33	13457 36
49	312	37 66	11749 92
50	323	26 00	8398 00
51	316	18 33	5792 28
52	517	17 00	8749 00
53	364	20 33	7400 12
54	358	31 00	11098 00
55	666	17 66	11761 56
56	575	15 66	9004 50
57	459	19 33	8872 47
58	512	30 66	15697 92
59	367	23 33	8562 11
60	365	40 33	13520 45

N = 60 S(XY) = 726232.40

Product moment correlation = $r = \dfrac{\frac{S(xy)}{N} - \bar{x}\bar{y}}{\sigma_x \sigma_y}$

$S(xy) = 726232.40$

$N = 60$

$\bar{x} = 429.9166$

$\bar{y} = 28.9166$

$\sigma_x^2 = 19705.1504$

$\sigma_y^2 = 80.6804$

$$r = \frac{\frac{726232.40}{60} - 429.9166 \times 28.9166}{\sqrt{19705.1504 \times 80.6804}} =$$

$$= \frac{-328.7263}{1260.8} = -0.260$$ Sig. at 5 % level (negative correlation).

Correlation between Simple Reaction Time and Performance Time.

Group II

Nr of subj.	X S. R. T.	Y Sum of perfor. times.	XY
1	195	14 66	1688 70
2	259	22 00	5698 00
3	250	20 66	5165 00
4	231	25 66	5927 46
5	232	24 66	5721 12
6	199	13 00	2587 00
7	240	27 00	6480 00
8	293	30 33	8886 69
9	172	33 33	5732 76
10	238	33 00	7854 00
11	252	21 33	5375 16
12	214	31 33	6704 62
13	194	13 66	2650 04
14	272	18 66	5075 52
15	214	17 00	3638 00
16	276	13 33	3679 08
17	279	16 66	4648 14
18	288	19 00	5472 00
19	254	13 33	3385 82
20	226	22 33	5046 58
21	250	26 00	6500 00
22	331	21 00	6951 00
23	230	16 00	3680 00
24	311	19 00	5909 00
25	307	20 00	6140 00
26	237	18 33	4344 21
27	304	19 66	5976 64
28	169	17 66	2984 54
29	308	22 00	6776 00
30	207	12 00	2484 00
31	257	13 00	3341 00
32	293	18 33	5370 69
33	258	8 66	2234 28
34	290	21 66	6273 50
35	225	13 66	3073 50
36	191	11 33	2164 03
37	205	15 66	3210 30
38	274	15 66	4290 84
39	192	11 66	2238 72
40	354	8 66	3065 64

Correlation between Simple Reaction Time and Performance Time.

Group II

continuation.

Nr of subj.	X S. R. T.	Y Sum of perfor. times.	XY
41	178	19 66	3499 48
42	209	22 00	4598 00
43	174	18 66	3246 84
44	266	42 33	11259 78
45	235	16 00	3760 00
46	286	11 00	3146 00
47	210	13 00	2730 00
48	272	21 33	5801 76
49	194	10 66	2068 04
50	165	9 00	1485 00
51	241	14 33	3453 53
52	265	17 33	4592 45
53	182	17 00	3084 00
54	213	14 00	2982 00
55	213	28 33	6034 29
56	289	21 66	6259 74
57	278	10 00	2780 00
58	176	9 33	1642 08
59	295	24 66	7274 70
60	228	14 00	3192 00

N = 60 S(XY) = 271331.11

$$\text{Product moment correlation} = r = \frac{\frac{S(xy)}{N} - \bar{x}\bar{y}}{\sigma_x \sigma_y}$$

$S(xy) = 271331.11$

$N = 60$

$\bar{x} = 242.5$

$\bar{y} = 18.5888$

$\sigma_x^2 = 1850.3333$

$\sigma_y^2 = 47.3837$

$$r = \frac{\frac{271331.11}{60} - 242.5 \times 18.5888}{\sqrt{1850.3333 \times 47.3837}} =$$

$$= \frac{14.4010}{296.1} = 0.048 \text{ Not Significant.}$$

Correlation between Simple Reaction Time and Performance Time.

Group of nursing staff.

Nr of subj.	X S.R.T.	Y Sum of perfor. times.	XY
1	147	18 66	2743 02
2	182	12 00	2184 00
3	197	9 00	1773 00
4	212	10 66	2259 92
5	167	7 66	1279 22
6	180	11 66	2098 80
7	171	6 66	1138 86
8	144	18 00	2592 00
9	184	5 00	920 00
10	159	14 00	2226 00
11	191	16 33	3119 03
12	169	7 66	1294 54
13	177	9 33	1651 41
14	178	8 00	1424 00
15	167	9 33	1558 11
16	197	9 66	1903 02
17	180	21 33	3839 40
18	149	15 66	2333 34
19	163	28 66	4671 58
20	165	13 66	2253 90
21	181	7 66	1386 46
22	172	27 66	4757 52
23	184	17 33	3188 72
24	160	7 66	1225 60
25	170	7 00	1190 00
26	167	8 66	1446 22
27	156	14 00	2184 00
28	164	9 66	1584 24
29	182	3 66	666 12
30	155	5 66	877 30
31	188	8 66	1628 08
32	190	7 33	1392 70
33	214	10 00	2140 00
34	210	8 33	1749 30
35	195	10 33	2014 35
36	218	4 66	1015 88
37	165	9 66	1593 90
38	191	11 00	2101 00
39	215	12 33	2650 95
40	171	15 33	2621 43

Correlation between Simple Reaction Time and Performance Time.

Group of nursing staff.

continuation.

Nr of subj.	X S. R. T.	Y Sum of perfor. times.	XY
41	203	6 66	1351 98
42	183	11 33	2073 39
43	189	10 33	1952 37
44	176	10 00	1760 00
45	217	8 33	1807 61
46	184	5 66	1041 44
47	190	16 66	3165 40
48	198	16 33	3233 34
49	200	14 33	2866 00
50	168	20 00	3360 00
51	203	8 33	1690 99
52	156	13 00	2028 00
53	183	21 33	3903 39
54	181	12 66	2291 46
55	181	13 33	2412 73
56	204	4 66	950 64
57	175	8 33	1457 75
58	199	22 00	4378 00
59	175	7 00	1225 00
60	165	8 33	1374 45

N = 60 S(XY) = 124996.86

Product moment correlation = $r = \dfrac{\frac{S(xy)}{N} - \bar{x}\bar{y}}{\sigma_x \sigma_y}$

$S(xy) = 124996.86$

$N = 60$

$\bar{x} = 180.7833$

$\bar{y} = 11.6388$

$\sigma_x^2 = 370.3151$

$\sigma_y^2 = 28.8785$

$$r = \frac{\frac{124996.86}{60} - 180.7833 \times 11.6388}{\sqrt{370.3151 \times 28.8785}} =$$

$$= \frac{-20.8405}{327.09} = -0.0678$$ Not Significant.

CHAPTER VII.

KINESTHETIC DISCRIMINATION EXPERIMENT.

(1) The present experiment was carried out before the main experiment and four independent groups of subjects were used, each consisting of 30 adult subjects.
The mean I Q of each group being 40, 50, 60 and 106.

The results are particularly important in showing a significant difference between the mean scores of the 40 and 50 I.Q. groups.

(2) As these two groups are very close to the two groups of subjects which took part in the main experiment with regard to their mean I.Q's (40 & 50 and 42, 76, & 49.5) respectively, some of the conclusions drawn from the present experiment seem to be applicable to the conclusions drawn from the main experiment.

1. Purpose of the experiment.

The main purpose of this experiment was to investigate the relationships, if any, between groups of subjects of various intelligence levels and their ability to discriminate different weights. In addition it was expected that some other relevant information would be obtained on the following:- (1) the influence of misleading visual clues on the Kinesthetic discrimination; (2) ability to improve performance with practice; (3) Degree of variability in dealing with stimuli; (4) Relationship between the distribution of actual scores in particular trials to the distribution of these scores according to chance; differences in scores which would be attributed to sex differences.

(2) Selection of subjects and division of them into four groups.

120 adult subjects were selected, 60 females and 60

males. 90 subjects were mentally defective patients, selected on the basis of their results obtained on the Revised Stanford-Binet Intelligence Scale, the 30 remaining subjects were members of the nursing staff selected at random by the Chief Male Nurse and the Matron.

Mentally defective subjects were divided according to their I.Q's into three groups. Each group consisted of 30 subjects, 15 male and 15 female patients. The I.Q's of the first group varied between 38 and 42, the mean I.Q. being 40; the I.Q's of the second group varied between 48 and 52, the mean I.Q. being 50 and the I.Q's of the third group varied between 58 and 62, the mean I.Q. being 60. The I.Q's of the group composed of the nursing staff were not measured, but it could be safely assumed that the mean I.Q. of this group would be somewhere about 106. This last figure represents the mean I.Q. of 96 prospective student nurses and nursing scholars tested by the writer in the last three years on the Revised Stanford-Binet test, Form L.

3. Apparatus and procedure.

The experiment consists of two parts. For the first part of the experiment 5 tins of the same shape and colour were used. Each tin was 4 inches in height and 3.3 inch in diameter. Each tin was loaded with a different quantity of sand so that their weights were 200, 112, 224, 336 and 248 gm. respectively. For the second part of the same experiment, intended to measure the influence of misleading visual clues on Kinesthetic discrimination, 5 bottles of the same shape and colour were used. Each bottle was the standardized type for 4 fluid ounces, amber coloured. The bottles were filled to various levels with different fluids up to the weights 200, 212, 224, 236 and 248 gm respectively. In the table below are given; number of each bottle, its weight, type and level of fluid in each bottle.

Nr of bottle	1	2	3	4	5
Weight of the bottle in gm.	224	200	248	236	212
Type of fluid	Oil	Ether	Sugar Syrup	Glycerine.	Paraldehyde.
Level of fluid in inches.	2.65	2.55	2.35	2.25	2.05

4. Procedure and Scoring.

Each subject, when sitting comfortable at the table, has been presented with the five tins and has been asked to lift them up and point to the heaviest one. When he did so, that tin was taken away and he was asked to select the second heaviest, and so on. Two minutes after the first part of the experiment was completed he was presented with five bottles, and the procedure was repeated. For each correctly selected tin or bottle in each trial he was given one point; for each failure 0 was given, so that each subject could score between 0 and 8 points in both parts of the experiment. In the course of the experiment it was also recorded whether he has used one or both hands throughout the whole experiment, or whether he switched from one hand to the other, or from one hand to both in the course of his performance.

It should be mentioned that the pilot experiment was carried out previously with 30 members of the nursing staff using tins with weights of 200, 210, 220, 230 and 240 gm. respectively. As the results were poor and as the experiment was intended not only for normal but for defective subjects as well it was decided to increase the difference in weights from 10 gm. up to 12 gm. In order to avoid practice effects all members of staff taking part in the pilot experiment were excluded from the subsequent investigation.

In analysing the results we can confine ourselves to the following:-

1) The sum of the scores obtained by each subject and each group in both parts of the experiment; 2) calculation of the statistical significance between the means of the groups, and finally, some of the results which seem to be complimentary to the conclusions drawn from the main experiment. The results given below for each group were arranged so that the subjects from 1 to 15 were males and from 16 to 30 females.

Kinesthetic discrimination.

Group of 30 subjects with mean I.Q. of 40.

Nr of subject	X Sum of Scores	X^2
1	2	4
2	3	9
3	3	9
4	3	9
5	3	9
6	4	16
7	3	9
8	2	4
9	4	16
10	1	1
11	4	16
12	3	9
13	5	25
14	1	1
15	5	25
16	2	4
17	5	25
18	3	9
19	3	9
20	3	9
21	3	9
22	6	36
23	3	9
24	2	4
25	6	36
26	5	25
27	2	4
28	5	25
29	2	4
30	5	25
N = 30	S(X) = 101	$S(X^2)$ = 294

$$\text{Mean} = \bar{X} = \frac{S(X)}{N} = \frac{101}{30} = 3.066$$

Kinesthetic discrimination

Group of 30 subjects with mean I.Q. of 50.

Nr of subject	X Sum of scores	X^2
1	5	25
2	5	25
3	6	36
4	5	25
5	5	25
6	5	25
7	5	25
8	6	36
9	1	1
10	6	36
11	4	16
12	7	49
13	4	16
14	3	9
15	4	16
16	7	49
17	5	25
18	3	9
19	5	25
20	3	9
21	3	9
22	8	64
23	2	4
24	5	25
25	5	25
26	3	9
27	8	64
28	6	36
29	2	4
30	5	25
N = 30	S(X) = 141	$S(X^2)$ = 747

$$\text{Mean} = \bar{X} = \frac{S(X)}{N} = \frac{141}{30} = 4.7$$

Kinesthetic discrimination.

Group of 30 subjects with mean I.Q. of 60.

Nr of subject	X Sum of scores	X^2
1	5	25
2	5	25
3	6	36
4	6	36
5	3	9
6	7	49
7	5	25
8	4	16
9	6	36
10	6	36
11	5	25
12	4	16
13	5	25
14	5	25
15	6	36
16	4	16
17	6	36
18	3	9
19	4	16
20	5	25
21	3	9
22	5	25
23	4	16
24	7	49
25	7	49
26	6	36
27	5	25
28	6	36
29	4	16
30	7	49
N = 30	S(X) = 154	$S(X^2) = 832$

$$\text{Mean} = \bar{X} = \frac{S(X)}{N} = \frac{154}{30} = 5.01$$

Kinesthetic discrimination.

Group of 30 subjects composed of nursing staff.

Nr of subject	X Sum of scores	X^2
1	5	25
2	6	36
3	4	16
4	8	64
5	8	64
6	8	64
7	8	64
8	7	49
9	5	25
10	4	16
11	5	25
12	6	36
13	8	64
14	6	36
15	4	16
16	8	64
17	6	36
18	5	25
19	6	36
20	6	36
21	5	25
22	6	36
23	5	25
24	3	9
25	7	49
26	6	36
27	7	49
28	6	36
29	5	25
30	6	36
N = 30	S(X) = 179	$S(X^2) = 1121$

$$\text{Mean} = \bar{X} = \frac{S(X)}{N} = \frac{179}{30} = 5.966$$

Calculation of significant difference between means.

As the means of the groups which have to be compared are relatively small we shall use the formula:

$$t = \frac{|\bar{x}_1 - \bar{x}_2| \sqrt{\frac{1}{N'}}}{\sqrt{S(x_1^2) - \frac{[S(x_1)]^2}{N_1} + S(x_2^2) - \frac{[S(x_2)]^2}{N_2}}}$$

I.

Group of 30 subjects with mean I.Q. of 40.

$N = 30$
$S(X_1) = 101$
$S(X_1^2) = 294$
$\bar{X}_1 = 3.066$

Group of 30 subjects with mean I.Q. of 50.

$N = 30$
$S(X_2) = 141$
$S(X_2^2) = 747$
$\bar{X}_2 = 4.7$

$t = 2.0502$ Sig. at 5% level.

II

Group of 30 subjects with mean I.Q. of 50

$N = 30$
$S(X_1) = 141$
$S(X_1^2) = 747$
$\bar{X}_1 = 4.7$

Group of 30 subjects with mean I.Q. of 60

$N = 30$
$S(X_2) = 154$
$S(X_2^2) = 832$
$\bar{X}_2 = 5.01$

$t = 0.8164$ Not sig.

III.

Group of 30 subjects with mean I.Q. of 60

$N = 30$
$S(X_1) = 154$
$S(X_1^2) = 832$
$\bar{X}_1 = 5.01$

Group of 30 subjects composed of nursing staff.

$N = 30$
$S(X_2) = 178$
$S(X_2^2) = 1121$
$\bar{X}_2 = 5.966$

$t = 1.367$ Not Sig.

Two things may be observed from the table below, first, the influence of the misleading visual clues on the performance improvement due to practice and second, differences in weight discrimination due to sex.

	Sum of scores			
	Male subjects		Female subjects	
	Tins	Bottles	Tins	Bottles
Group with mean I.Q. 40	24	22	30	25
" " " " 50	32	39	33	37
" " " " 60	39	39	44	32
Nursing Staff.	44	48	45	42
Sum of scores for each group in each part of the experiment.	139	148	152	136
TOTALS.	287		288	

A number of tentative suggestions could be made on the basis of the above results.

(i) There is practically no difference between the sum of scores obtained by male and female subjects in the two parts of the experiment.

(ii) In the first part of the experiment concerned with weight discrimination between various tins, female subjects obtained better results than males.

In the second part of the experiment concerned with bottles, males obtained better results than female. These differences between the sexes, although statistically not significant, may suggest that female subjects are slightly better in the discrimination of different weights, but that they are also more suggestive to misleading visual clues, and because of this they do not show improvement in the course of the experiment. On the other hand, male subjects, although not as good as females initially, are less suggestible in respect of misleading visual clues and thus they subsequently show some improvement, probably due to practice.

(iii) With regard to the two groups with mean I.Q's of 40 and 50, the first one does not show any improvement, either male or female subjects. On the other hand, male and female subjects belonging to the second group show improvement, which could be only described as due to practice.

The degree of variability in dealing with the presented weight is given in the table below.

	Frequency of response		
	One hand employed throughout the whole performance.	Switch from one hand to another or from one to both hands.	Both hands employed throughout the whole performance.
Group with mean I.Q's of 40	26	3	1
Group with mean I.Q's of 50	17	10	3
Group with mean I.Q's of 60	14	11	5
Group of Staff	10	11	9

Although it is difficult to draw any valid conclusions from the results given in the above table, nevertheless the pattern of responses seems to be of some value. It could be observed that as we move up the intelligence scale the groups tend to show greater variety of responses. It should also be noticed that the widest gap in responses is between groups with mean I.Q's of 40 and 50 respectively.

The problem of the exact evaluation of the results in Kinesthetic discrimination appears to be complicated because successive as opposed to simultaneous comparisons seem to involve two entirely different mental operations.

The analysis of the relationship between the distribution of actual scores in particular trials to the distribution of scores with a chance distribution is very instructive and interesting. As the scores of each subject were recorded in each trial, it is easy to find the sum of scores of each trial for every group. It is equally easy to calculate how the actual sum of the scores would be distributed by chance; in the table below is given the distribution of actual scores in particular trials in the first and second part of the experiment, and also their distribution according to chance.

Distribution of scores in the first part of experiment (Tins).

	Scores			
Number of trials.	1	2	3	4
Group with mean I.Q's of 40	8	11	17	18
" " " " " 50	12	12	19	22
" " " " " 60	20	17	23	23
Group of Staff.	20	22	23	24

Distribution of the sum of the above scores according to chance.

	Scores			
Number of trials	1	2	3	4
Group with mean I.Q's of 40	8.41	10.51	14.02	21.03
" " " " " 50	10.13	12.66	16.88	25.32
" " " " " 60	12.93	16.16	21.15	32.33
Group of Staff.	13.87	17.33	23.11	34.67

Distribution of scores in the second part of the experiment (Bottles)

	Scores			
Number of trials	1	2	3	4
Group with mean I.Q's of 40	8	8	18	13
" " " " " 50	12	19	22	23
" " " " " 60	14	14	21	22
Group of Staff	21	21	24	24

Distribution of the sum of the above scores according to chance.

Number of trials	Scores			
	1	2	3	4
Group with mean I.Q's of 40.	7.3	9.15	12.2	19.09
" " " " " 50	11.84	14.80	19.74	29.61
" " " " " 60	11.06	13.83	18.44	27.73
Group of Staff	14.02	17.53	23.37	35.06

If we present the actual scores obtained in particular trials and the chance distribution of these scores in the form of a graph, then a number of interesting observations may be made.

(i) On the whole the curve of the actual scores appears to accompany the curve of scores distributed by chance in the group on the lower end of the intelligence scale. When we move upwards these curves diverge more and more. The factor responsible for this growing divergency is obviously the fact that more correct judgements of weight are being made.

(ii) The above curves seem to be more close to each other in the first part of the experiment dealing with tins than in the second part dealing with bottles. In this case, the factor determining the divergency between the curves seem to be the suggestibility of the subjects caused by the various levels of fluid in the bottles.

(iii) If we analyse the relationship between both curves in particular trials then the picture is as follows: in trial 1, 2 and 4 both curves are close to each other as far as the group with mean I.Q's of 40 is concerned. As we gradually move upwards in the intelligence scale the gaps between both curves within those particular trials gradually widen. The divergency between the curves is the widest with the group of staff. The relationship between both curves is reversed with regard to trial number 3, i.e. the gap between curves is the widest in the least intelligent group and it gradually closes as we move upwards through defective groups towards the group composed of nursing staff. It is impossible, however, to offer any explanation of this phenomenon at present.

(iv) We should also mention the shape of the curves representing the actual scores. The shape of this curve is more curved with the groups of defective subjects and it gradually becomes straight when we come to the group of nursing staff.

Summing up the results of the above experiment it can be said that there is a significant difference, as far as Kinesthetic discrimination is concerned, between scores obtained with groups with mean I.Q's of 40 and 50 respectively. There is no significant difference between the scores obtained with groups with mean I.Q's of 50 and 60, there is also no significant difference between the group with mean I.Q. of 60 and the group made up of the nursing staff.

The other differences between the results of the four groups under investigation, such as the influence of misleading visual clues on the weight discrimination, ability to improve performance due to practice, etc., are statistically not significant, but they seem to be more pronounced between groups with mean I.Q's of 40 and 50 respectively than between any other groups.

CHAPTER VIII

DISCUSSION OF RESULTS AND CONCLUSIONS.

The most significant outcome of this investigation is concerned with the establishing of the relationship between the pressure exerted by the hand while drawing some simple geometrical figures and the performance time. These two variables correlate in the two groups of mental defective subjects at various intelligence levels and also in the third group composed of nursing staff.

There is no positive correlation between S.R.T. and pressure, or between the S.R.T. and performance time in any of those three groups, except a slight negative correlation between the S.R.T. and performance time which is present in Group I.

If attention is focused in turn on the difference between means of various tests obtained with the three groups under investigation it can be said that there is statistically significant difference between the means of the S.R.T. pressure, and performance time, between the Group II, and the Group made up of Nursing Staff; there is also significant difference between means of the S.R.T. pressure, performance time, verbal and performance tests, between both groups composed of mentally defective subjects. There are also differences between the two last mentioned groups with regard to their drawing ability, scholastic attainments test, ability to improve drawing by practice and the tendency to draw a smaller figure in each subsequent drawing, although these differences were not interpreted statistically. It seems there is hardly any need for the statistics with regard to the comparison of the drawing ability, and scholastic attainments of both groups.

The respective tables show that the existing differences are too big to be non significant. The other two items, i.e. ability to improve drawing by practice, and tendency to draw a smaller figure in each subsequent attempt, although interesting, seem to be of lesser importance for the present investigation.

The gap between the two groups composed of mentally defective subjects, which are significantly different in every test given to these groups, is further accentuated by the results of the Kinesthetic Discrimination experiment. The first two groups at the lower end of the intelligence scale which took part in this experiment, as far as their mean I.Q's are concerned, are very close, to the two groups which took part in the main experiment, and the conclusions drawn from the main experiment can therefore be supplemented by the conclusions drawn from the Kinesthetic experiment. Here again there is significant difference in ability to discriminate between various weights between the two groups composed of mentally defective subjects with their mean I.Q's of 40 and 50 respectively. There is no significant difference between the group of defectives with a mean I.Q. of 60 and the group of nursing staff. With regard to other differences, as for instance, rigidity of responses, obtained in the Kinesthetic Discrimination experiment with various groups, these are much more pronounced between the two groups with mean I.Q's of 40 and 50 respectively, than between the groups with mean I.Q's of 50 and 60 or between the group with mean I.Q. of 60 and the group made up of nursing staff.

If a very general joint conclusion is drawn from the results obtained in the main and Kinesthetic Discrimination experiments with regard to the groups at various intelligence levels, then it can be said that there is a much wider gap or difference in results of various tests between the two groups with their approximate mean I.Q.'s of 40 and 50 respectively, than between any other neighbouring two groups higher up the intelligence scale. At this particular level of the intelligence scale (between 40 and 50 I.Q's) all results of various tests rise very steeply, at a different rate of course, and then their further rise, with regard to the groups of subjects placed higher up the intelligence scale, becomes only slight, resembling in some way the gradual rise of the intelligence curve. In order to illustrate the different rate of rise of the curve of results obtained of various tests, the results of drawing, pressure and weights discrimination tests should be considered. As far as drawing of simple geometrical figures is concerned there seems to be no difference between the results of Group II and the results of nursing staff. With regard to pressure test, both these groups are significantly different. As far as weights discrimination is concerned there is no significant difference between the results obtained with the group of mental defective subjects whose mean I.Q. is 60 and the results of nurses. Although the curves illustrating diagramatically the results of various tests obtained with groups at various levels of mental development, are all rising sharply with regard to the two groups with mean I.Q's of 40 and 50 respectively, some of them may, however, be no parallel to each other or to the gradually rising curve of intelligence.

In summing up, it may be said that an individual, whether normal or defective, may achieve various results in different tests, some of them, in spite of differences in their rate of rising and the position to the curve of intelligence, may, and they do, correlate. Results of other tests obtained with mental defective subjects, which do not correlate with each other may show considerable variations with regard to results obtained with the so called normal group.

It may safely be said that results of the same test carried out with various groups at different levels of mental development if connected together would not form a curve parallel to the gradually rising curve of intelligence.

Another important outcome of this work is concerned with the drawing ability of simple geometrical figures by the defective subjects at different levels of mental development. Results of drawing tests carried out on 120 mental defective subjects within the range of I.A.'s 38 - 57 on the Revised Stanford-Binet Intelligence Scale Form L show that there are various degrees of difficulty involved in drawing of different angles. The easiest to perform is the right angle, and the most difficult is an obtuse angle.

Ability to draw the last mentioned angle is highly correlated with an ability to draw a diamond. The correlation between ability to draw an appropriate angle and the simple geometrical figure is not limited to an obtuse angle and a diamond. It seems that the positive correlation is maintained with regard to subjects at the lower end of the intelligence scale between an ability to draw a curved line and circle, between a right angle and a square, and between an acute angle and a triangle. It is possible to say that an ability to draw any simple geometrical figure is directly determined by the ability to perform an essential part of it, i.e., a curved line or an appropriate angle. This generalization appears to be fully justified by our drawing experiments, observations derived from routine testing of mental defectives, and by the analysis of drawing requirements embodied in the Revised Stanford-Binet test. According to the above test an average child of three years should be able to draw a circle, of five years a square, and of seven a diamond. Observations with regard to various degrees of difficulty involved in the drawing of different angles by mental defectives seem to be in complete agreement with the drawing requirements of the Stanford-Binet test. Both of them, drawing requirements of this test, and observations, point out the existence of various distinct levels of mental development through which any normal child would pass in the course of his maturation, but a mental defective subject may fail on some of them according to the degree of his arrested motor development, which may be, however, in some variance with his intellectual achievements.

It can be concluded that the failure to draw some angle, or a simple geometrical figure by the mental defective adult subject, depends on the attained level of his motor development.

It cannot be agreed that the failure to draw a simple figure can be adequately explained in terms of the existing perceptual errors.

Analysis of drawing failures, ability of all patients who failed to draw a diamond, to identify it among other figures, and results of the inquiry, indicate that the perception, however defective it may be among our subjects, cannot be held responsible for failures to draw simple figures.

By postulating various levels of motor development the failures to draw some angle or simple geometrical figures as being above the attained level of motor development of an individual can be explained to a certain extent; but this explanation has only a limited value because of its high degree of generalization. If it is accepted that the failure to draw some particular angle or simple figure cannot be explained in terms of perceptual error, but by the attained level of motor development, then the next logical step is to analyse in detail some particular motor level. It is possible to venture the simple statement that any angle or simple figure can be drawn by the subject if he is able to execute the necessary hand movements, any failure in drawing is determined by his inability to make the appropriate hand movements.

Circular movement such as is required when a circle or a rounded line is drawn can be performed by an average child of three years old, that means at a very early stage of maturation. The most characteristic feature of that particular movement is the gradual change in the direction of the moving hand while the number of muscle fibres imvolved remain roughly the same throughout the whole motion.

Angular movements such as are required when various angles or simple geometrical figures are drawn, are at a more advanced level of motor development. They are characterised by the relatively sudden change in the direction of the moving hand, and a considerable variation in the number of muscle fibres engaged in their execution. The angular changes in the direction of the moving hand are effected by the harmonious interaction between two distinct groups of muscles, i.e., between flexors and extensors. Drawing of various angles or figures involved various degrees of interaction between the two above mentioned groups of muscles.

The interaction between flexors and extensors, as required when angular changes in the direction of the hand are executed, seems to be adversely affected by the phenomenon which I call 'dominance of flexors' This phenomenon can be explained more clearly by the following example: when a right angle is drawn by a normal person the vertical arm is executed by a flexion of a thumb, the index and the middle finger; the horizontal arm is subsequently executed by the extension of the wrist and fore-arm muscles; drawing of this angle by some mentally defective subjects show rounding up of the angle itself which is due to their inability to inhibit flexor activity at the turning point. Some other drawings by defective subjects show not only the rounding of the angle but also the curving upwards of the horizontal arm of a right angle; which seems to be due to their inability to inhibit flexors for a prolonged time. (Chapter III, Figure 2, drawing 1).

In short, the action of flexors overlap the action of extensors at one or more points of the performance, resulting in failure to draw an appropriate angle.

Results of the drawing experiment carried out with the mental defective subjects show various degrees of difficulty involved in drawing of right, acute and obtuse angles; a right angle was the easiest to draw, and an obtuse angle the most difficult. This could be easily explained, if, during an attempt to analyse movements involved in the drawing of some particular angle, the previously mentioned concept is kept in mind, i.e., dominance of flexors. The change in direction of the moving hand, as required when a right angle is drawn, is effected by the interaction between relatively weak flexors and powerful extensors. Because of the considerable difference in the number of the muscle fibres involved in each of the two separate hand movements, initial dominance of flexors is subsequently successfully neutralized by the powerful extensors, and hence a remarkable success of defective subjects in the drawing of a right angle. The change in direction of the moving hand, as required when an acute angle is drawn, is effected by the interaction of flexors and extensors in which the number of muscle fibres involved is roughly the same. Dominance of flexors is much more pronounced then, and the success of drawing is declining. The most complicated movement however, is required when the drawing of an obtuse angle is attempted. The vertical arm of this angle is effected by the flexion of the three previously mentioned fingers, the second arm is effected not only by the extension of the wrist and forearm muscles, but also by the further, however diminished flexion of the three fingers. The change in the direction of the moving hand as required when an obtuse angle is drawn is almost impossible for many young children and low grade defectives, and, because of that, drawing failures are most frequent in our experiment.

Dominance of flexors with regard to an unsuccessful attempt to draw an obtuse angle is manifested in two principal ways during the drawing of the second arm of the angle. When the flexion of the three fingers cannot be sufficiently diminished, then the subject is drawing a straight line instead of an obtuse angle; and when subjects counteract this flexion by the extension of wrist and forearm muscles too strongly then he is drawing a right angle instead of an obtuse angle. It should be noted that the drawing of an obtuse angle requires, at first, the employment of flexors and then the extensors, similarly to the drawing of right and acute angles, but also a considerable and gradual modification of flexor activity when extensors play their part.

Inability to execute that particular complicated movement, which is temporary in normal young children and which may be permanent in some defectives, is the crucial factor determining the failure to draw an obtuse angle or a diamond.

On the whole, it may be said that the motor development of an average child passes through certain distinct levels. They are manifested in the progressive ability of a child to execute, at first, the curved line or a circle, then a right angle or a square, and finally an obtuse angle or a diamond. The motor development of some of the mentally defective subjects can be arrested at any of those levels. Failure to perform any of the above mentioned figures is due to the inability of an individual to form the appropriate motor patterns. The chief difficulty in the formation of motor patterns seems to be due to the dominance of flexors over extensors. An average child in the course of maturation can and does overcome to a considerable extent this dominance of flexors, but some of the mentally defective subjects are able to do this only to a very limited extent.

In chapter one of this work we attempted to analyse a variety of skills, and it was observed that in any one of them there were always present the three following factors:- force or pressure exerted by muscles, performance time, and variations in the direction. These three factors were accepted as the essential components of any skilled performance. It was also said that the degree of simple skill depends on the harmonious interplay between these three components, which are in turn closely interrelated. Any impairment in any of them would influence directly the other two, and indirectly the degree of skill. These three essential components of any skill seem to be primarily innate, and because of that they can be improved by practice only to a limited extent.

It is now possible to consider the results of the drawing performance obtained with the two groups of mentally defective subjects at different levels of development and with one group composed of nursing staff, and review those results in the terms of skill.

It was possible to establish experimentally the relationship existing in all three investigated groups, between the pressure exerted by the hand during the drawing and its performance time. This relationship is manifested in a positive correlation between these two variables, and it is independent of the developed mental level of a group. All three groups are significantly different as far as means of the pressure and performance time tests are concerned. Group I and Group II are also significantly different with regard to their drawing ability of simple geometrical figures, which, as was stated before, is determined by an ability to perform angular changes in the direction of the moving hand. The two groups, composed of mental defective subjects at different levels of mental development, are significantly different with regard to the three essential components of skill, moreover the two of them are correlated, it is possible to say, that these two groups are also significantly different with regard to the degree of attained skill. The differences between both groups are not limited to the purely motor skill as an ability to draw simple geometrical figures, but there is a wide difference between them with regard to the more complicated skilled performance, as for instance an ability to write. Both groups composed of mentally defective subjects are not only significantly different in the simple skilled performance, as writing ability, they are also significantly different in every test carried out with both groups, even in those tests which cannot be labelled as the skilled performances, as for instance, the S.R.T. and the Kinesthetic Discrimination test.

It seems to be possible to make some generalization by saying that if the two groups of subjects are at different levels of skill, i.e., are significantly different with regard to the three essential components of skill, they are also bound to differ significantly in any other performance. It does not matter whether more or less skill is required.

Group II and the Group composed of the nursing staff are significantly different with regard to results obtained with pressure and performance tests, but differences in drawing ability of both groups seems to be somehow unclear. In spite of the fact that all subjects of Group II were able to draw an obtuse angle and only very few of them failed to draw a diamond, it cannot be said that Group II is equal to the Group made up of nursing staff with regard to drawing ability. Members of nursing staff drew all required angles without visible effort and without failures.* Subjects of Group II drew an obtuse angle, although correctly, with a considerable effort; there were also some failures, however, infrequent, not only in drawing of a diamond, but even in the drawing of right and acute angles. These 'unnecessary' drawing failures and also effort in the

* See Chapter V for times.

execution of an obtuse angle, occuring in Group II indicate that the motor patterns were poorly established at that particular level of development and hence the regression to the earlier and simpler levels where motor patterns were better developed. Because of differences between both groups with regard to the performance time and pressure exerted while drawing, which are significant, and because of the difference in the ability to vary hand direction, which is less obvious but nevertheless existent, even in such a simple performance as drawing, it can be concluded that both groups are significantly different in their respective skills.

Results of pressure and performance time tests obtained with the Group of nurses vary considerably between individual subjects. Their ability to vary hand direction seems to be less variable in the simple drawing performance, but it is conceivable that with the introduction of more skilled performances than the drawing, and with the use of precise measuring instruments, it would be possible to find as wide variations in that particular ability at an adult level as there are among young children and mentally defective subjects. It seems that any skill would depend ultimately on the interrelation and interplay between the pressure, performance time, and the ability to vary direction, which were defined as the essential components of skill. These three skill-components, the time of their maturation and deterioration seem to be innate and particular to each individual. Practice may modify to a certain extent an interplay between them and possibly the durability of their efficient operation in one's life-time.

The present work, initiated by a few observations and basic assumptions made in connection with unsuccessful attempts to draw a diamond by a mentally defective subject, consisted of a series of experiments carried out with the three groups of subjects at various levels of their intellectual and motor development. The results of these experiments prove that these groups are significantly different with regard to every test given to them, and that there is a definite relationship betwen the hand pressure exerted during the drawing and its performance time existing in each of these groups. The results of drawing experiments seem to point out that an ability or inability to draw simple geometrical figures, i.e. to execute the appropriate hand movements, is motor and not perceptual in origin. The three factors, i.e., the hand pressure, performance time, and ability to vary hand direction, manifested in any drawing performance seem to be closely interrelated. They also appear to be the essential components of any motor skill.

The last statement, or rather a tentative hypothesis, put these experiments into a very large framework embracing a variety of repetitive complex motor responses which can be roughly defined as skill. It also opens new vistas into an investigation of skill, not only at various intellectual levels, but also with different age groups. It seems to be possible to make here some suggestions with regard to the direction of experimental investigation of skill.

(a) Skill maturation.

The following problem has to be answered: when does an average child reach the adult level with regard to the three essential components of skill, and which of them is the first to maturate? An experiment of young children with the use of pressure and performance time recording apparatus may be of some help.

(b) Skill deterioration.

There can be little doubt that the skill of an individual deteriorates as his age advances; there are a decreasing number of oldish people in jobs which require motor skill; an age limit is necessary in the case of persons who have to undergo special training in the armed services; a considerable difficulty is encountered by the aged in the learning of some skill. These fully support the above statement.

It seems to be possible to design and carry out a series of experiments with oldish people which may indicate their time of deterioration and which one of the three essential components of skill is the first to deteriorate.

(c) Comparison between Groups of skilled and unskilled subjects.

As a matter of scientific interest it should be possible to investigate and compare the results of hand pressure, performance time, and ability to vary hand direction, in two groups of subjects at approximately the same level of intelligence and of about the same age. The first group of subjects should possess a high degree of some manual skill, and the second should be composed of subjects who are known to be 'clumsy' and devoid of physical skill. If my concept of skill, and particularly its composition is right, the positive results of such an experiment could be of some value with regard to the selection and training of individuals for skilled occupations.

(d) Effects of practice on skill.

It seems to be easy to investigate the three essential components of skill in a large group of persons who are about to commence training in some manual skill, and to repeat the same experiment some time later when they have reached a certain level of proficiency. It would be very interesting to see whether there is any correlation between their progress in acquisition of skill and improvement in skill components.

(e) Ability to vary hand movements.

This particular ability was partly investigated in my experiments at the lower end of the intelligence scale. It would be interesting to explore it in average skilled or unskilled individuals. The use of pursuit meters may be quite useful.

(f) Dominance of flexors.

It was previously suggested that ability to vary hand direction is directly determined by the degree of interaction between flexors and extensors. Failures or impairments in variation of hand movements were attributed to the distortion of the interaction between the two groups of opposite muscles, due to dominance of flexors. Many experiments can be designed and carried out to check this concept, which, if proved, may be a considerable contribution to the body of knowledge.

In the course of this work I encountered many problems which I was unable to pursue or to explain, as for instance the tendency to decrease each subsequent drawing in size, or the influence of epileptic fits and drugs on the Simple Reaction Time. It does not matter whether these topics are somehow connected with skill, or whether they constitute separate problems, in either case, they deserve some attention by experimental psychologists.

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ABSTRACT.

It was observed that mental defectives, who were unable to draw a diamond, revealed an associated decrease in their performance time and increase in hand pressure.

Closer study of the failure to execute a diamond suggested the hypothesis that the chief difficulty consisted in the patient's inability to draw the obtuse angles, i.e. to make that particular angular change in the direction of the moving hand.

Subsequent experiments confirmed the close relationship between the ability or inability to draw a diamond and the drawing of an obtuse angle. Various degrees of difficulty involved in the drawing of different angles were also demonstrated. These experiments also indicated that patients with an I.Q. below 38 could not draw an obtuse angle or a diamond, while subjects with an I.Q. above 57 could.

The main experiment consisting of a battery of tests was carried out on two groups of defectives and a third group composed of nursing staff. The I.Q.'s of both groups of defectives varied between 38 and 57. The subjects in the first group could not while those in the second group could draw an obtuse angle.

The results of the main experiment showed a significant difference between the means of the three groups for Simple Reaction Time, Pressure and Performance Time tests. There was also a significant difference between the means of verbal and practical tests of both groups of defectives. In all three groups positive correlation was established between the Pressure and Performance Time tests.

On the whole, drawings, as other skilled performances, were shown to depend on the ability of the individual to maintain and vary direction and pressure, and the correct timing of these activities. These three factors would appear to be the essential components of skill studied.

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