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Feeble-mindedness and mechanical aptitute.

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FEEBLE-MINDEDNESS AND MECHANICAL APTITUDE

DION 1940

F E E B L E - M I N D E D N E S S

AND

M E C H A N I C A L A P T I T U D E

BY

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Introduction

(1) Definition of Feeble-Mindedness--What is feeble-mindedness? The terms 'idiot', 'imbecile' and 'moron' are part of the vocabulary of the average man of to-day. Every locality has its proverbial idiot the 'foolish boy' or the 'silly girl' who bears the brunt of every practical joke in the neighborhood. There is the slow-witted imbecile, who, because of his many eccentricities, is a welcomed source of conversation to the townspeople. The irrational behavior of the dull moronic eighteen-year old boy is a constant source of worry and despair to his parents.

What do these unfortunates lack that their normal neighbors have? Psychologists have all given an answer, in different phraseology perhaps, but the gist of which is--'a lack of mental capacity to make the necessary adjustments that society demands'. The definition of feeble-mindedness in most general use and accepted by the American Association for the Study of the Feeble-Minded is as follows:--"A feeble-minded person is one who is incapable, because of mental defect existing from birth or from an early age, of competing on equal terms with his normal fellows, or of managing himself or his affairs with ordinary prudence."[1] Abraham Myerson expresses

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(1) E. B. Huey, Backward and Feeble-Minded Children, p. 6.

feeble-mindedness as follows:--"As a symptom, it is a congenital or early acquired lack of mental ability manifested by an incapacity or diminished capacity to remember to learn to carry out the functions of mind in the degree we recognize as normal."[2]

(2) Measurement of Feeble-Mindedness--The first significant work in the measurement of feeble-mindedness was that of the two French psychologists, Dr. Binet and Dr. Simon, at the Sorbonne, in 1905. They devised a series of tests in which a standard basis was developed to determine mental ability for a given chronological age. They found that children are not only normal and feeble-minded. Instead, their research proved that there were many grades of intelligence, ranging from low feeble-minded--idiocy, to high intelligence--genius.[3]

(3) Classification of Feeble-Mindedness--After considerable experimentation, Terman perfected the Binet-Simon Tests. He perfected a scale in which an average child of a given chronological age would test exactly at that age.[4] This he expressed in terms of intelligence quotient (I.Q.) which is nothing more than the ratio between the mental age and chronological age. The I.Q. designates how retarded

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(2) Mabel A. Elliott and Francis E. Merrill, Social Disorganization, p. 529.

(3) Lewis M. Terman, The Measurement of Intelligence, p. 41.

(4) Ibid., p. 53.

or advanced a child of a given age is in comparison to a normal child of the same age.

According to Terman's classification intelligence is grouped into the following categories:--[5]

I. Q.	Classification
Above 140	"Near" genius or genius
120 - 140	Very superior intelligence
110 - 120	Superior intelligence
90 - 110	Normal, or average intelligence
80 - 90	Dull normal
70 - 80	Borderline, sometimes classifiable as dullness, often as feeble-mindedness
Below 70	Definite feeble-mindedness
60 - 70	Moron, high
50 - 60	Moron, low
25 - 50	Imbecile
Below 25	Idiot

Using Terman's scale as a basis, all other classifications include these general groupings:--Idiots, imbeciles, morons and borderline. Howard Potter's classification is an ideal one. He groups mental defectives according to intelligence as idiots, imbeciles, and morons. He subdivides these into neurologic endocrinopathic, and idiopathic types. He further qualifies these as to personality characteristics, which are primitive in the idiot

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(5) Lewis M. Terman, Op. Cit., p. 79.

group, simple in the imbecile group and complex in the moron group. He makes further provision for classifying mentally defectives who are psychotic and the occasional case who may be erroneously regarded as mentally defective[6] but all of these groupings are medico-psychological and, as such, are not within the scope of this study. Suffice it to note that his preliminary grouping is based after Terman.

Sherlock states that the best classification on practical lines is that of the Royal College of Physicians of London and adopted by the Royal Commission on the Feeble-Minded.[7] Quote:

> Idiots, i.e., persons so deeply defective in mind from birth or from an early age that they are unable to guard themselves from common physical dangers, such as in the case of young children would prevent their parents from leaving them alone.
>
> Imbeciles, i.e., persons who are capable of guarding themselves against common physical dangers but who are incapable of earning their own living by reason of mental defect existing from birth or from an early age.
>
> Feeble-Minded, i.e., persons who may be capable of earning a living in favorable circumstances, but are incapable from mental defect existing from birth or from an early age: (a) of competing on equal terms with their normal fellows; or (b) of managing themselves and their affairs with ordinary prudence.
>
> Moral Imbeciles, i.e., persons who from an early age display some mental defect coupled with strong vicious or criminal propensities on which punishment has little or no deterrent effect.

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(6) Howard W. Potter, "The Classification of Mental Defective", Mental Hygiene, vii (July, 1923) Pp. 509-520.

(7) E. B. Sherlock, The Feeble-Minded, p. 185-186.

The American Association for the study of the feeble-minded accepts the following:[8]

> The term idiot is used to designate those of mental age up to and including two years; imbecile, those of from three to seven years, inclusive. For those from seven to twelve a new term has been invented; they are now called morons.

(4) Types of Feeble-Mindedness--In proposing to classify mentally defectives according to types let it be said that every psychologist has his pet classificatory system. However, the following grouping seems to be the most common and most understandable classification, and contains the chief characteristics of other type combinations:[9]

> (1) the microcephalic--i.e., mental deficiency accompanied by an abnormally small skull;
>
> (2) the hydrocephalic, characterized by an enlarged skull and commonly called "water on the brain";
>
> (3) the paralytic; and (4) the traumatic--i.e., due to accidental brain injury;
>
> (5) Mongolian idiocy, which is characterized by physical features similar to the Mongolian;
>
> (6) syphilitic amentia--which is usually the result of congenital syphilis.
>
> (7) Feeble-minded epileptics are sometimes given as an additional classification, although there is little conclusive evidence that epilepsy produces feeble-mindedness.
>
> (8) the borderline defective, although properly speaking not truly feeble-minded, also constitutes a significant number of the subnormal group.

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(8) Henry H. Goddard, Feeble-Mindedness Its Causes and Consequences, p. 4.

(9) Mabel A. Elliott and Francis E. Merrill, Social Disorganization, p. 329.

(5) Causes of Feeble-Mindedness--Seventy-seven per cent of the feeble-minded are so because of heredity. Such is the conclusion arrived at by Dr. Goddard as the result of his famous research at the Vineland Institution in New Jersey. The remaining twenty-three per cent are the result of non-hereditary factors. Of this number he ascribes nineteen per cent to accident causes and the remainder to no apparent cause.[10] Space is lacking here to go into detail on his study. The reader is urged to look up his findings not only in his "Feeble-Mindedness; Its Causes and Consequences", but also in "The Kallikak Family"[11] which is a classic study of hereditary factors in connection with feeble-minded.

The non-hereditary factors may be given as; "(1) trauma induced by injury at birth, (2) acute lesions resulting from poisons and infections, (3) faulty functioning of the endocrine glands, and (4) malnutrition".[12]

(6) Treatment of the Feeble-Minded--The care of the feeble-minded has been an indispensable feature of the educational program of every town, city and state. Statistics show that special treatment of these defectives

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(10) Henry H. Goddard, Op. Cit., pp. 437-465.

(11) Henry H. Goddard, The Kallikak Family, PP. xv and 121.

(12) Mabel A. Elliott and Francis E. Merrill, Op. Cit., p. 333.

has progressed in this country in the last decade. This has come about by the realization of the importance of adjusting instructional procedures to meet individual differences. With this development has come forth special facilities for the mentally retarded. For many years, extreme cases were taken care of in special institutions for feeble-minded. The remainder were either allowed to go to school until of legal age to withdraw or huddled together in a so called special class with no special significance attached to it other than the fact that they could not keep up with the others. Now, special facilities, other than the ordinary school curriculum, are being provided for these exceptional children resulting in increased opportunities for all.

The organization for the proper care and treatment of the feeble-minded is dependent for its success upon the cooperation of public educational systems with private and public residential institutions for the feeble-minded. Educators have done much in bringing about the conception that these institutions are a constituent part of any educational system.

A program for the care and training of mental defectives is now in operation in all but three states.[13]

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(13) Emery M. Foster, and Elise H. Martens, Statistics of Special Schools and for Exceptional Children, p. 3.

These are Arizona, Arkansas and Nevada. Such programs include some or all of the features outlined by Nellie L. Perkins, in 1923. The following is a summary of her plan.[14]

1. Clinics for diagnosis and psychiatric studies.

2. Hospitals and adequate medical care to include correction of physical defects whenever possible.

3. Adequate facilities for training special classes, state training schools, with provisions for hospital care and colonies for custodial types and defective delinquents.

4. Proper and intensive training over a long period, with the emphasis on habit training or character building.

5. Adequate and permanent supervision and the development of community responsibility, which means the development of a personnel of especially trained workers who are temperamentally suited to handle the defective.

A more definite program had been advanced, in 1920 in Ungraded. This program is given here to show the resemblance of policies advocated by psychological experts two decades ago. It has taken that length of time to see the realization of these techniques.

Quote:[15]

> A state program for the care, training, segregation and supervision of mental defectives may be conceived as being: 1, institutional: 2, extra institutional.

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(14) Nellie L. Perkins, "The Defective Child - What can Be Done for It", Mental Hygiene, (July, 1923) p. 503.

(15) "General Policies for the Care of Mental Defectives", Ungraded, Vol. v No. 4 (January, 1920) Pp. 90-91.

1. Institutional. Institutional facilities must be adequate or else the program will fail in most particulars. These facilities will vary somewhat in type, according to the section of the country, the particular interests of superintendents and boards of managers and whether the institutions are intended to provide training, permanent segregation of low grade inmates or long continued segregation of defective delinquents. There should be detention and observation hospitals where certain cases of suspected mental defect might be sent for careful examination and classification.

2. Extra-institutional. Extra-institutional activities for a state wide program for mental defectives include the mental examination of backward school children, special classes in the schools, mental clinics, both fixed and movable, after care of special class pupils, special training of teachers in normal schools, census and registration, identification and supervision of all uncared for defectives and the selection of those who most need institutional care. It should stimulate scientific research. In some of these matters the work of the commission should be merely in the line of cooperation with other state departments, notably the State Department of Education. In the matter of school children, it should begin its activities when the Department of Education leaves off. For example, the examination of the backward school children is essentially the function of the Education Department, but the Commission for mental defectives should be kept informed of the results of these examinations, and should assist in proper provision, when this is necessary, for these cases after the school period. Mental clinics will be referred to in more detail in a subsequent paragraph (not included here). They should be operated for the present, at least, in conjunction with other State Departments, notably the State Hospital Commission and the State Department of Health. A census and registration should be made by the commission, -------. The commission should have attached to it social workers to provide for the extra-institutional supervision of all uncared for defectives in the community.

As stated above such programs are now in operation in forty-five states caring for a total of 121,510 subjects. (Table I.)

Table I*

Summary for Continental United States for Public and Private Residential Schools for the Mentally Deficient and for Special Schools and Classes in City School Systems, 1935-36.

Item	Mentally deficient
1	2
Number of public residential schools.....	71
Number of private residential schools.....	59
Number of city school systems reporting enrollments in special classes.....	643
Teachers:	
Public residential.....	742
Private residential.....	530
City school systems.....	4,671
Total.....	5,943
Enrollment:	
Public residential.....	18,834
Private residential.....	3,055
City school systems.....	99,621
Total	121,510

A typical plan of organization is found in Massachusetts. This state was one of the first states to pioneer in the care and treatment of the feeble-minded and is now one of the thirteen states[16] with

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* Emery M. Foster and Elise H. Martens, Statistics of Special Schools and Classes for Exceptional Children, pp. 10-11.

(16) Elise H. Martens, Organization for Exceptional Children Within State Departments of Education, pp. 20-32.

an adequate type of program. Figure 1 outlines in part the type of organization in Massachusetts.

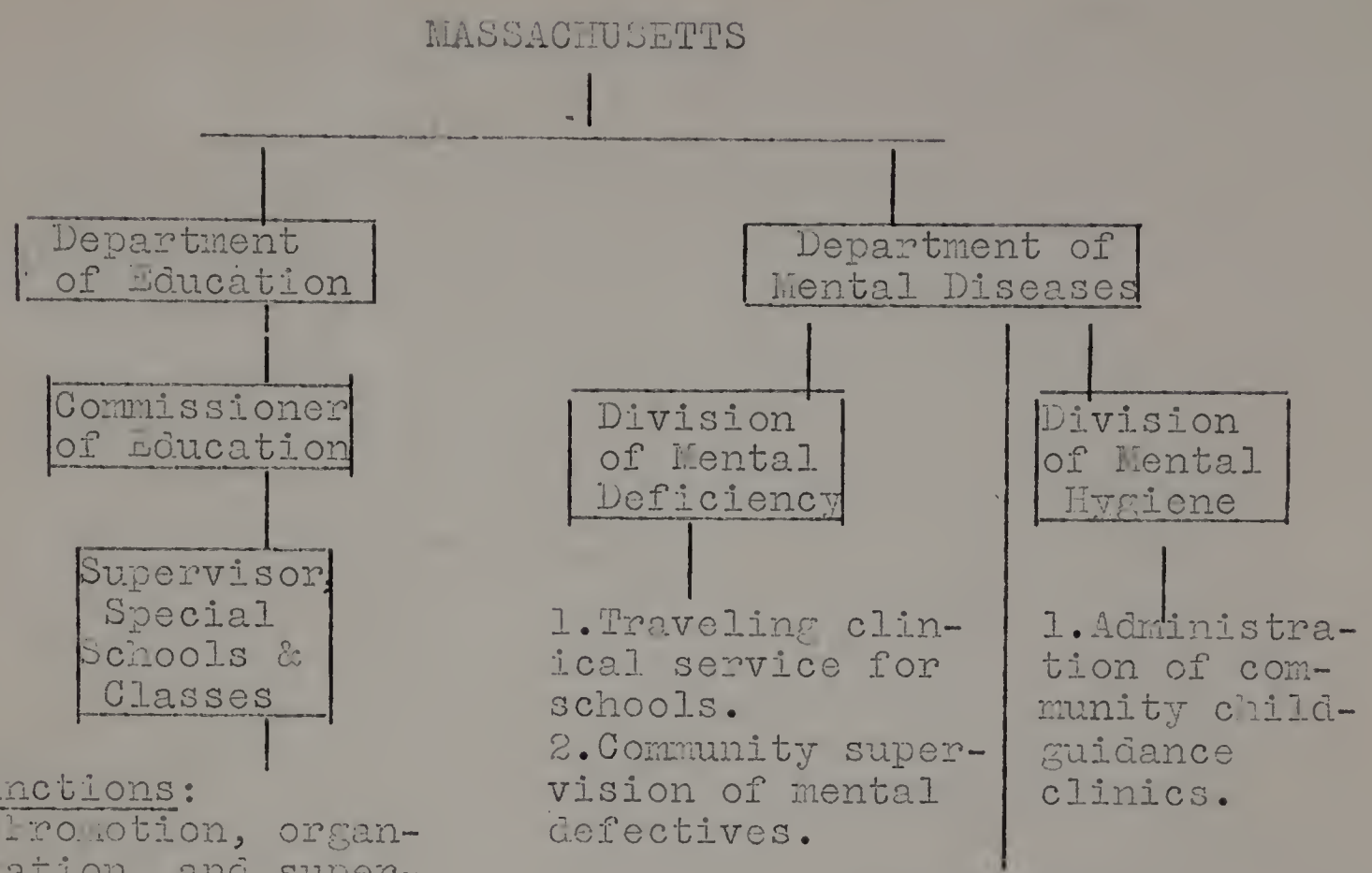

Figure 1*

* Elise H. Martens, Organization for Exceptional Children Within State Departments of Education, p. 25.

A scrutiny of the latest available figures, 1935-1936, shows that Massachusetts provides for 8,693 mentally deficient[17], a figure exceeded only by New York and Pennsylvania.[18] These subjects are cared for in over 550 special classes[19] and seven institutions. See Table II for the list of these institutions and their enrolment.

(7) Educational Treatment of Feeble-Mindedness--The limited capacities of the feeble-minded suggest adaptations in the educational function of the regular school curriculum. The feeble-minded usually reach the saturation point in academic work before the fifth grade so that further training for them needs consideration. The problem of what to teach these pupils has been in the foreground for the last three decades or so.

This study was undertaken in an effort to discover a solution to that problem. Can the feeble-minded profit by vocational training and become sufficiently self sufficient to find a place in the community? Have they sufficient mechanical aptitude to warrant training? If so, how can these aptitudes be ascertained? Which

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(17) Emery M. Foster and Elise H. Martens, Statistics of Special Schools and Classes for Exceptional Children, p. 12.

(18) Ibid., p. 13.

(19) "Survey of Special Education for Atypical Children", Massachusetts Department of Education, p. 2.

Table II*

PUBLIC AND PRIVATE RESIDENTIAL SCHOOLS FOR MENTALLY DEFICIENT AND EPILEPTICS, 1935-36

MASSACHUSETTS

Institution	Pupils: Intelligence-Distribution: Idiot	Imbecile	Moron	Borderline	Others	Total	Number who are epileptic	Pupils enrolled for school work: Number enrolled in--: Kindergarten and sense training	General elementary	Total	Number enrolled in special fields: Music	Physical training	Manual training	Household arts or science	Other occupational instruction
The Freer School, Arlington, Heights.....	-	5	5	--	-	10	-	3	7	10	8	10	6	4	-
Belchertown State School Belchertown.....	2	55	111	16	-	184	-	74	110	184	162	160	49	51	3
Standish Manor School, Halifax.	1	1	5	--	-	7	-	--	6	6	3	5	6	6	-
Perkins School, Lancaster.....	-	13	22	--	-	35	6	13	22	35	24	35	12	12	-
Clarke School, Newton.....	-	3	4	1	4	12	-	--	12	12	24	12	12	7	-
Walter E. Fernald State School, Waverley.....	-	38	247	36	-	321	-	52	269	321	---	---	--	--	-
Wrentham State School, Wrentham.....	-	--	---	--	-	480	-	89	375	464	104	392	--	52	72

* Emery M. Foster and Elise H. Martens, Op. Cit., p. 156-157.

testing schemes will best determine these aptitudes?

Chapter II is an attempt to summarize the extent of special mechanical aptitudes that can be expected of the feeble-minded.

FEEBLE-MINDEDNESS

and

MECHANICAL APTITUDE

Chapter II

Feeble-Mindedness and Mechanical Aptitude

What is to be done with the problem of the increasing number of feeble-minded? This need not be appalling if the aptitude possibilities of these unfortunates are better recognized and their abilities better trained. With this in mind psychologists agree that a great number of the feeble-minded can find social adjustment.

(1) Feeble-Mindedness and Mechanical Aptitude--

One of the tasks of education today is to see that every child, feeble-minded, dull or brilliant, uses to the fullest extent whatever capacities he may possess. These capacities or special aptitude are usually present before entering school. They must be given an opportunity to manifest themselves. The work of the schools is to push these innate aptitudes not create them. Education cannot bring genius out of a child whose I.Q. is 70. Genius just isn't there. However, it can produce the growth of certain special aptitudes that the same child may possess.

Lacking intelligence the feeble-minded manifest certain mechanical aptitudes that, when properly trained and developed, enable them to become self-supporting. Dr. Goddard states that in the "training of the hand,--

manual training, industrial training", the mentally defectives achieve success.[1]

Paterson and others state that "the possibility of salvaging individuals with low I.Q.'s possessing mechanical ability is so obviously worth following up as to require no further defense".[2]

(2) Summary of Reports--Naturally, mechanical aptitude is not present in all mentally retarded boys. However, previous studies show that a fair percentage of the feeble-minded have mechanical ability and can take care of themselves.

In a follow-up study of eighty feeble-minded, borderline and seriously backward pupils Inez Neterer came to the following conclusions:[3]

1. The majority of the Special Class pupils go into industry.

2. The special class pupil fills the blind alley job--the essential odd jobs--that are undesirable to an ambitious individual, but absolutely unavoidable in industry.

3. They seem unable to take responsibility.

4. Those who go into industry are, on the whole self-supporting in ordinary circumstances, particularly if under some sort of supervision.

5. There is a large per cent of drifters both in regard to residence and in regard to the job held, due largely to personal characteristics.

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(1) Meta L. Anderson, Education of Defectives in the Public Schools, p. 12.

(2) D. G. Paterson, R. M. Elliott, L. D. Anderson, H. A. Toops, and E. Heidbreder, Minnesota Mechanical Ability Tests, p. 302.

(3) Inez Neterer, "Follow Up Study of Special Class Pupils", Ungraded, V, No. 5-6-7 (Feb. 1920) Pp. 116-119, (March, April, 1920) Pp. 152-156.

6. As a class they are unable to cope with new or unforeseen conditions--

a. Only twenty-five per cent save money to any extent.

b. External conditions in industry affect them largely.

7. Some become valuable citizens.

Dr. Walter E. Fernald reported in 1908:[4]

> Some of the institutions where only the brightest class of imbeciles are received, and where the system of industrial training has been very carefully carried out, report that from twenty per cent to thirty per cent of the pupils are discharged as absolutely self-supporting. In other words at other institutions, where the lower grade cases are received, the percentage of cases so discharged is considerably less. It is safe to say that not over ten per cent to fifteen per cent of our inmates can be made self-supporting, in the sense of going out into the community and securing and retaining a situation, and prudently spending their earnings.... But it is safe to say that over fifty per cent of the adults of the higher grade who have been under training from childhood are capable, under intelligent supervision, of doing a sufficient amount of work to pay for the actual cost of their support, whether in an institution or at home.

Miss Farrell's study contained in Miner's "Deficiency and Delinquency"[5] was made from a report of 350 boys and girls out of the 600 children formerly in the ungraded classes in New York City during an eight-year period. Twenty-eight per cent earned $5.00 a week or more and thus possibly survived independently. Of a group of 333, 86 were at home, 192 employed, 31 unemployed and 3 married.

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(4) James B. Miner, Deficiency and Delinquency, p. 76.

(5) Ibid., p. 79.

In a more recent study Dr. Fernald substantiated his earlier findings in a report on 470 discharged male patients from Waverley.[6]

> Of the 470 males--twenty-eight were earning a good living without supervision. All of these were morons----Their weekly wages ran from $8.00 to $38.00. They were working as teamsters, elevator man, city laborer, factory worker, farm laborer, soda clerk, tinsmith, carpenter, painter, chauffeur, machinist, etc. One is in business for himself as a sign painter, a trade he learned at the school. ---One had saved $2,000.; another had bought a house. Eleven of the group had married, and of these marriages there were nine children.
>
> Eighty-six were steadily working for regular wages, living at home, closely supervised by their relatives. Nearly every one was a moron although there were a few high imbeciles. Their average wage was $9.60, and they were employed in thirty-nine different occupations. None of these were troublesome severally or criminally.
>
> A group of seventy-seven males of low moron and high imbecile grade and of various ages were able to do more or less work at home, but received no wages.
>
> Fifty-nine males of idiot and imbecile grade, unable to do any work, were living at home, and the families seemed able and desirous of continuing the home care of their permanently infantile offspring.
>
> Fifty-four had died.
>
> The remainder (sixty-eight) were either readmitted to Waverley or arrested or committed to other institutions as incorrigibles.

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(6) Walter E. Fernald, "After-Care Study of the Patients Discharged from Waverley for a period of Twenty-Five Years", Ungraded, V, No. 2 (November, 1919) pp. 25-31.

Miner[7] quotes another study conducted in Detroit. Quoting:

> In Detroit among one hundred children over sixteen years of age who had attended its special classes and been out of school not over five years, twenty-seven had been arrested, but thirty-nine of the boys had been at work and received an average wage of $7.00 per week.

(3) Deductions from Evidence--This evidence of the earning capacity of the feeble-minded brings about the following deductions:

1. There is sufficent manifested mechanical ability in the feeble-minded to warrant attention.

2. There is no need of isolating in institutions all people of low intellectual grades.

3. There is need for further study to determine and to develop to capacity the potentialities of the feeble-minded.

(4) What Can the Feeble-Minded Do?--From the above reports it is also gathered that only the higher types of the feeble-minded, namely, the morons and border-line, and a few high imbeciles, may have sufficient ability to find a place in the community; and that the tasks they can perform are those of a manual nature requiring, for the most part, traits perfected mechanically through habit and imitation.

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(7) James B. Miner, Op. Cit., p. 79.

Goddard attempts to classify industrially the feeble-minded. This industrial classification is given in Table III .

Table III*

Goddard's Industrial Classification

Mental age	Industrial Capacity	Grade	
Under 1 year	(a) Helpless. (b) Can walk. (c) With voluntary regard	Low	
1 year	Feeds self. Eats everything	Middle	Idiot
2 years	Eats discriminatingly (food from non-food)	High	
3 years	No work. Plays a little		
4 years	Tries to help	Low	
5 years	Only simplest tasks	Middle	
6 years	Tasks of short duration. Washes dishes.		Imbecile
7 years	Little errands in the house. Dusts	High	
8 years	Errands. Light work. Makes beds.		
9 years	Heavier work. Scrubs. Mends. Lays bricks. Cares for bath-room.	Low	
10 years	Good institution helpers. Routine work.	Middle	
11 years	Fairly complicated work with only occasional oversight.		Moron
12 years	Uses machinery. Can care for animals. No supervision for routine work. Cannot plan.	High	

A fair indication of the occupational rank of the feeble-minded is shown in this classification.

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* Henry H. Goddard, Feeble-Mindedness--Its Causes and Consequences, p. 581.

To compare this with other occupations Beckman's[8] scale is given here. This scale is intended to indicate the rank of an occupation on the basis of the intelligence, capacity or skill, education and training required for its pursuit. Five grades are contained:

1. Unskilled Manual Occupations.

2. Semi-skilled Occupations.

3. (a) Skilled Manual Occupations.
   (b) Skilled White-collar Occupations.

4. (a) Sub-professional Occupations.
   (b) Business Occupations.
   (c) Minor Supervisory Occupations.

5. (a) Professional (Linguistic) Occupations.
   (b) Professional (Scientific) Occupations.
   (c) Managerial and Executive Occupations.

Of these one can readily see that the feeble-minded are limited to grade one and most of grade two. In order to indicate what type of work can be expected of the mentally defectives Beckman's list of representative occupations for grades one and two is included in Table IV .

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(8) Walter Van Dyke Bingham, Aptitudes and Aptitude Testing, p. 97.

Table IV*

Beckman's List of Representative Occupations in Grades 1 and 2 of the Occupational Scale.

Grade	Occupations
1	Unskilled Manual Occupations:
	Farm laborers; lumbermen, raftsmen and woodchoppers; laborers (construction, manufacturing, road, warehouse, etc.); long-shoremen; sailors and deckhands; garage, trucking and stable hands; deliverymen; newsboys; soldiers, sailors and marines; attendants (pool rooms, bowling alleys, golf clubs, etc.); char-women, maids and cleaners; janitors and sextons; porters; messengers and office boys and girls.
2	Semi-skilled Occupations:
	Fishermen and oystermen; mine operatives; filers, grinders, buffers; stationary firemen; furnace and smelter men; oilers; operatives in chemical and allied industries brick, tile, lime, and cement works foods, beverages, and tobacco blast furnaces, rolling mills, iron and steel factories tin and enamel ware leather industries planing, woodworking, and paper mills cotton and other textile mills; draymen and teamsters; baggagemen; street, railroad and bus conductors; switchmen, flagmen, and yardmen; truck drivers and chauffeurs; firefighters; guards, watchmen, and doorkeepers; policemen; housekeepers and stewards; laundry workers; waiters.

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* Walter Van Dyke Bingham, Op. Cit., p. 98.

There are many other similar lists which a counselor will find of value. These may be found listed in Bingham's "Aptitudes and Aptitude Testing".[9]

Mental tests have shown how to recognize the feeble-minded and determine what degree of intelligence they possess. Next comes the need for a testing device to recognize mechanical aptitude. It is hoped that this study will be of assistance in this development and be of value to further research along this line.

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(9) Walter Van Dyke Bingham, Op. Cit., pp. 97-101.

THE EXPERIMENT

Chapter III

The Experiment

This study is an attempt to supply a needed background to recognize the mechanical possibilities of the feeble-minded. Aptitude testing has found its useful place in the field of psychological guidance. However, there has been an unusual disregard of aptitude testing techniques with children of low intellectual grade. In relation to this problem, it is hoped that puzzled counselors will benefit from the substance of the successive chapters.

(1) Statement of the Problem--This is an experiment to discover a battery of mechanical aptitude tests that will best recognize mechanical ability among the feeble-minded.

The procedure followed was thus:

1. The administration of a preliminary test battery.
2. The selection of a final battery in the light of two prime considerations, namely:
   a. That the tests should each correlate highly with an established aptitude criterion of success.
   b. That they should have a low correlation with each other.

(2) Selection of Subjects--At the outset the selection of a group of subjects seemed quite a problem but it worked itself out very readily. The subjects

were obtained from the special classes and general vocational classes in the Southbridge Public Schools. The cooperation of the superintendent and of the various teachers was something to be deeply appreciated.

For the purpose of this study the subjects had to be below the I.Q. of eighty. Some fifty individuals were found to meet this prerequisite. These pupils had been tested by state psychologists. Insofar as the testing had been done over a period of four years it became necessary for the sake of uniformity to retest the subjects. Consequently the Otis Intermediate was administered to the group and forty-two were chosen on the basis that they were the most likely to remain in the experiment to the end. However, three dropped out at various times and thirty-nine remained to make up the study.

The ages of this group ranged from thirteen years and seven months to seventeen years and six months with a mean age of sixteen years and two months. Figure 2 shows the frequency distribution of the ages. The I.Q.'s ran from forty-eight to seventy-nine with a mean of 65.9. Figure 3 contains the distribution and classification of the group. From this figure it is seen that there were eleven borderline (70 to 80) defectives, twenty-seven morons (50 to 70) and one imbecile (25 to 50). This

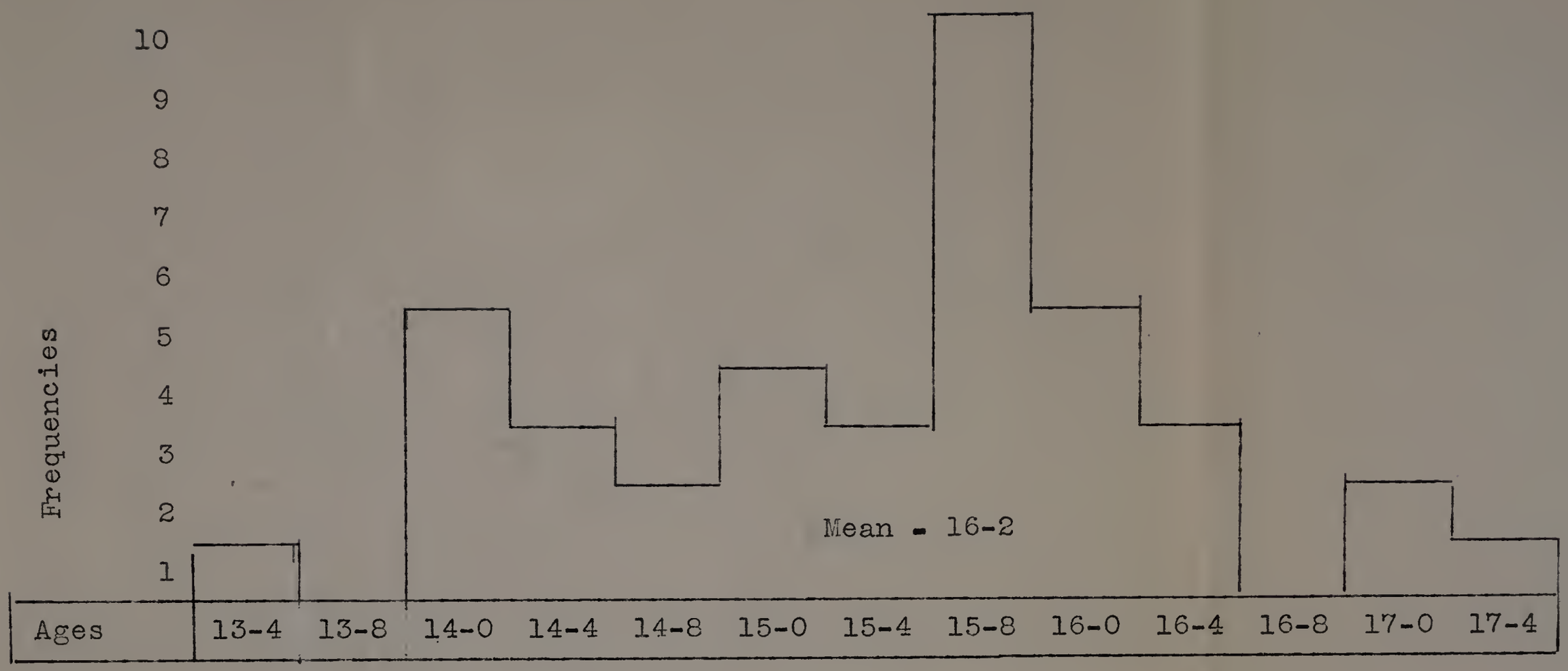

Figure 2

Histogram showing frequency distribution of chronological ages of the 39 boys in the experiment.

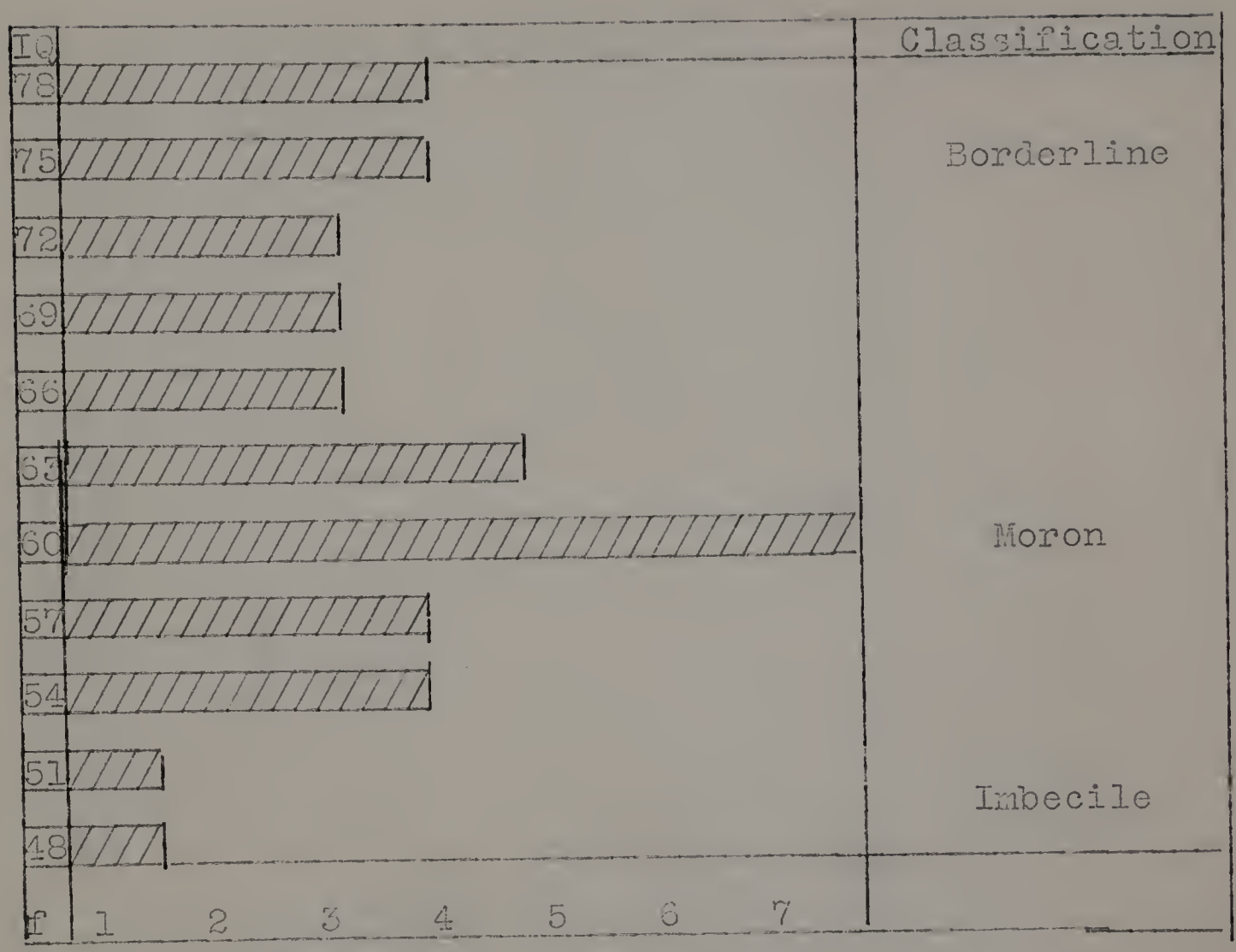

Figure 3

Bar graph showing frequency distribution and classification of I.Q. ratings of the 39 boys in the experiment.

indicated a mental age range of nine to twelve.

The I.Q. of the imbecile (46) showed that he had a mental age of nine and therefore classified as a high imbecile (Table III). There was no need of including anyone below this classification because previous surveys had shown that little or no mechanical aptitude is present at a Mental Age of eight or lower. In the process of this experiment this was justified in the fact that the one imbecile repeatedly achieved the lowest marks (Table VI).

(3) Selection of the Tests--In selecting a battery of mechanical aptitude tests many things had to be taken into consideration. The first task at hand was to determine which fundamental skills were desirable to predict the presence of a sufficient amount of mechanical aptitude. Naturally, many basic skills are essential to success in all manual occupations. Such skills involving the idea of creativeness, inventive genius and language were immediately disregarded because of their close relationship to intelligence. After considerable thought the following list was arrived at as the essentials to be tested:

1. Speed of movement
2. Speed in using hands
3. Speed in using fingers

4. Speed in discriminating odd sizes and shapes
5. Skill in manipulation
6. Eye-hand coordination
7. Steadiness of motor control
8. Ability to visualize patterns in two dimensions
9. Ability to deal with special relationships
10. Ability to visualize in terms of three dimensional spatial relationships
11. Mechanical information
12. Mental capacity
13. Minimum linguistic requirements.

This analysis done, the problem of finding a trial battery of tests to best measure these traits appeared. A survey of all available tests was made and a check revealed the following as the most representative battery:

1. The Wiggly Block[1]
2. The Finger Dexterity
3. The Tweezer Dexterity
4. The MacQuarrie Test
5. Minnesota Spatial Relations Board (A and B)
6. The Kent-Shakow
7. Minnesota Rate of Manipulation
8. Minnesota Assembly (Box B)
9. The Detroit Mechanical Aptitude Test

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(1) A description of these tests is included in Appendix I.

Table V

Showing What the Tests in the Experiment are Designed for

	Wiggly Block	Finger Dexterity	Tweezer Dexterity	MacQuarrie	Spatial Relations (Time)	Spatial Relations (Errors)	Kent Shakow	Manipulation (Placing)	Manipulation (Turning)	Assembly	Detroit
Speed to discriminate odd sizes and shapes					X		X				
Ability to visualize patterns in two dimensions					X		X				
Linguistic type of intelligence											X
Skill in manipulation		X	X		X			X	X	X	
Mental capacity	X			X							X
Eye-hand coordination			X			X			X		
Speed of movement		X	X	X	X			X	X	X	X
Ability to deal with special relationship	X			X	X		X			X	X
Speed in using fingers		X							X		
Steadiness of motor control			X	X		X					X
Speed in using hands								X			
Ability to visualize in terms of three dimensional spatial relationships	X			X						X	
Mechanical information										X	X

Table VI

Raw Scores of Experiment

Code Number	I.Q.	Teachers' Estimates	Wiggly Block	Finger Dexterity	Tweezer Dexterity	MacQuarrie	Spatial Relations (Time)	Spatial Relations (Errors)	Kent Shakow	Minnesota Assembly	Detroit	Manipulation (Placing)	Manipulation (Turning)
1	68	47	3.2	5.4	6.9	41	478	11	269	69	137	232	258
2	63	53	2.6	5.4	8.7	36	839	33	195	50	61	265	295
3	69	60	2.8	4.3	7.8	30	561	28	208	60	105	254	282
4	56	58	7.6	3.8	7.0	58	510	17	163	57	137	197	205
5	55	53	3.1	4.8	7.0	47	538	19	157	78	120	249	259
6	61	65	3.8	4.7	7.4	42	644	29	241	61	134	259	298
7	52	40	7.7	4.6	12.3	25	1280	41	579	20	50	320	533
8	70	81	*12.0	5.2	8.1	58	701	18	199	75	123	253	286
9	78	60	2.1	5.2	8.9	44	575	25	120	55	141	259	314
10	63	54	6.4	5.9	9.3	47	598	26	223	51	118	258	294
11	64	65	1.7	4.4	8.2	24	714	27	280	63	98	233	253
12	79	68	2.6	4.3	6.3	60	470	16	274	56	203	216	241
13	77	66	2.6	4.1	6.3	60	496	19	251	60	181	298	214
14	65	50	5.7	5.4	9.0	27	740	28	495	46	107	251	266
15	69	67	1.5	5.0	8.2	26	660	33	246	53	85	250	268
16	48	10	*12.0	*10.0	*17.0	14	*1300	*65	*800	13	54	*400	*550
17	60	53	6.3	4.3	6.6	32	776	21	482	21	101	239	265
18	61	60	3.5	4.4	8.2	51	518	32	125	67	131	228	257
19	75	45	3.5	5.5	10.6	58	642	26	301	58	144	237	264
20	77	71	1.1	5.4	7.7	58	631	20	220	49	113	246	306
21	60	50	5.0	5.0	6.9	48	553	24	309	49	125	237	257
22	68	65	2.2	4.1	7.9	37	550	17	297	53	164	220	237
23	76	58	2.4	4.1	6.4	46	398	14	121	80	140	241	234
24	74	63	3.3	4.4	6.3	51	477	18	195	66	142	225	248
25	67	45	10.0	4.7	8.0	40	688	36	272	40	149	241	277
26	74	58	11.0	3.2	7.3	49	599	23	312	55	180	227	276
27	57	55	7.1	4.6	8.7	40	618	18	255	51	104	245	296
28	62	65	4.4	4.7	8.0	48	476	20	318	54	118	228	253
29	55	40	8.4	3.6	6.8	47	751	38	222	35	107	238	358
30	64	67	2.5	4.0	8.0	29	762	32	293	66	116	248	275
31	62	50	6.2	5.2	10.2	37	680	34	340	53	120	267	377
32	59	30	9.5	9.1	16.6	36	1080	61	746	23	82	267	280
33	74	82	1.1	4.0	6.6	67	401	19	128	75	222	228	243
34	61	70	4.3	3.5	7.4	60	564	19	187	61	143	244	277
35	57	80	1.6	4.5	7.6	52	467	10	166	69	101	223	235
36	58	45	11.0	8.4	11.1	17	1111	32	428	33	67	381	405
37	79	71	4.6	4.6	6.4	42	498	25	138	58	144	223	258
38	54	50	*12.0	6.9	11.3	39	743	45	648	27	131	271	341
39	79	65	2.9	4.0	6.5	51	425	15	160	75	185	231	230

*Note--This indicates failure to complete the test in which case the lowest score was given.

Table V shows what skills each of these tests is designed to measure.

(4) The Criterion of Success--The best indication of the prognostic value of a test however, is that it must correlate highly with an established criterion of aptitude efficiency. Accordingly, the next step was to select such a criterion. An analysis of various criteria revealed the impossibility of measuring mechanical ability in all its aspects. In the first place, since the purpose at hand was a measurement of essential mechanical skills it became desirable to eliminate intelligence. If it became preferable to measure manipulative rather than informational mechanical ability a criterion of success would be found in an index of manipulative skills. This index seemed best expressed in terms of teachers' marks. A boy's success in shop work is largely due to his aptitudes and this is best indicated in his teacher's estimates of his ability.

Consequently the criterion of success was secured from the average of the marks of the teachers who had these boys in wood work, metal work, printing, painting and mechanical drawing. Having chosen a good objective criterion the experiment was ready to begin.

DATA OF THE EXPERIMENT

Chapter IV

Data of the Experiment

(1) Administration of the Tests--In the administration of the tests, the needed attention necessary to improve the accuracy of the resulting scores was taken into consideration. The details of administration--the preliminary arrangements, the working conditions, the instructions, the timing and the scoring were followed as meticulously as possible, in order to insure the greater likelihood that the results may be of real value to others.

A preliminary step to the conduct of the experiment was the administration of the Otis Intermediate, Form A Test of Mental Ability. For the sake of convenience in administrating this group test, the trial group of fifty subjects was divided into two groups of twenty-five, each group in turn taking the test. Of this number thirty-nine remained to complete the experiment. The resulting scores are contained in Table VI.

The grades representing the teachers' estimates of mechanical ability may be found also in Table VI. These grades represented the arithmetical average of the marks of six teachers on the basis of one to one hundred. Electricity, painting, wood work, metal work, mechanical drawing covered the courses from which an ability estimate was requested. Let it be understood

that these estimates were on the basis of manipulative mechanical dexterity rather than on skills involving inventiveness and intelligence.

The remaining tests, which constituted the preliminary battery of mechanical aptitude tests, were administered in this order: the Wiggly Block, the Finger Dexterity, the Tweezer Dexterity, the MacQuarrie, the Minnesota Spatial Relations Board (boards A and B), the Kent Shakow, the Minnesota Assembly (box B), the Detroit Revised Mechanical Aptitude Test, and the Minnesota Manual Dexterity (both the turning and the placing tests). In Table VI will be found the raw scores obtained in the total experiment. These are to be further discussed below in the results of each test.

(2) Recognition of Standards--In order to bring out the evidence that the central purpose of this experiment was to determine a suitable battery of tests to predict mechanical aptitude, it was necessary to discover the degree of relationship between tests and with the criterion. Correlation coefficients were computed, therefore, between all measures and tests. In view of the fact that these intercorrelations are so numerous it was desirable to include the results in tabulated form. A general survey of this evidence follows: Table VII contains the distributions of the

TABLE VII

DISTRIBUTION OF THE SCORES OF THE 39 BOYS IN THE EXPERIMENT

OTIS I.Q.		TEACHERS' ESTIMATES		WIGGLY BLOCK		FINGER DEXTERITY		TWEEZER DEXTERITY		MACQUARRIE		SPATIAL RELATIONS (TIME)		SPATIAL RELATIONS (ERRORS)		KENT SHAKOW		DETROIT		MANIPULATION (PLACING)		MANIPULATION (TURNING)		MINNESOTA ASSEMBLY	
INTERVALS	F	INTERVALS	F	INTERVALS	F	INTERVALS	F	INTERVALS	F	INTERVALS	F	INTERVALS	F	INTERVALS	F	INTERVALS	F	INTERVALS	F	INTERVALS	F	INTERVALS	F	INTERVALS	F
78-80	4	77-83	3	2.0- 1.1	5	3.6- 3.1	3	7.0-6.1	13	65-69	1	450-361	3	10-6	1	120-61	1	210-224	1	210-224	1	210-181	1	78-83	2
75-77	4	70-76	3	3.0- 2.1	9	4.2- 3.7	7	8.0-7.1	10	60-64	3	540-451	10	15-11	3	180-121	8	195-209	1	225-211	5	240-211	5	72-77	3
72-74	3	63-69	10	4.0-3.1	6	4.8- 4.3	14	9.0-8.1	8	55-59	4	630-541	8	20-16	12	240-181	8	180-194	3	240-226	11	270-241	14	66-71	5
69-71	3	56-62	6	5.0- 4.1	4	5.4- 4.9	9	10.0-9.1	1	50-54	4	720-631	8	25-21	5	300-241	10	165-179	0	255-241	11	300-271	11	60-65	5
66-68	3	49-55	9	6.0- 5.1	1	6.0- 5.5	2	11.0-10.1	2	45-49	7	810-721	5	30-26	6	360-301	5	150-164	1	170-256	6	330-301	2	54-59	7
63-65	5	42-48	4	7.0- 6.1	3	6.6- 6.1	0	12.0-11.1	2	40-44	6	900-811	1	35-31	6	420-361	0	135-149	9	285-271	1	360-331	2	48-53	8
60-62	7	35-41	2	8.0-7.1	3	7.2- 6.7	1	13.0-12.1	1	35-39	5	990-901	0	40-36	2	480-421	1	120-134	7	300-286	0	390-361	1	42-47	1
57-59	4	28-34	1	9.0- 8.1	1	7.8- 7.3	0	14.0-13.1	0	30-34	2	1080-991	1	45-41	2	540-481	2	105-119	7	315-301	0	420-391	1	36-41	1
54-56	4	21-27	0	10.0- 9.1	2	8.4- 7.9	1	15.0-14.1	0	25-29	4	1170-1081	1	50-46	0	600-541	1	90-104	4	330-316	1	450-421	0	30-35	2
51-53	1	14-20	0	11.0-10.1	2	9.0-8.5	0	16.0-15.1	0	20-24	1	1260-1171	0	55-57	0	660-601	1	75-89	2	345-331	0	480-451	0	24-29	1
48-50	1	7-13	1	12.0-11.1	3	9.6- 9.1	1	17.0-16.1	2	15-19	1	1350-1261	2	60-56	0	720-661	0	60-74	2	360-346	0	510-481	0	18-23	3
						10.2- 9.7	1			10-14	1			65-61	2	780-721	1	45-59	2	375-361	0	540-511	1	12-17	1
																840-781	1			390-376	1	570-541	1		
																				405-391	1				
MEAN	65.9		57.9		5.1		4.9		8.6		43.5		658.8		25.9		272.6		125.5		249.5		285.4		54.1
MDN.	64.5		58.8		3.9		4.7		7.6		44.5		612		23.5		255		125.3		242.1		268.9		56.1

scores in the experiment as well as the means and the medians. In Table VIII is given all intercorrelations. Scatter diagrams showing the distributions in the correlations will be found in Appendix II.

All correlations in this study were computed by the Pearson-Product Moment Method. The formula in terms of symbols is:

$$r = \frac{\frac{\Sigma xy}{N} - CxCy}{\sigma_x \sigma_y}$$

The formula used for the multiple correlation (R) with four variables is as follows:[1]

$$R_{1.234} = \sqrt{1 - \left[(1-r^2_{14})(1-r^2_{13.4})(1-r^2_{12.34})\right]}$$

Before attempting to interpret the data of the experiment it is necessary to recognize a standard for judging the meaning of a correlation coefficient. The correlation must be high enough with the criterion to justify the acceptance of a test as an adequate index of mechanical ability.

In this connection Patterson and others[2] state:

> In intelligence tests, validity correlation coefficients are usually from +.40 to +.60, very seldom are coefficients +.60 and +.70 reported; and at present colleges and universities are

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(1) Frederick E. Croxton and Dudley J. Cowden, Applied General Statistics.

(2) D. G. Paterson, K. M. Elliott, L. D. Anderson, H. A. Toops, and E. Heidbreder, Minnesota Mechanical Ability Tests, p. 204.

Table VIII

Intercorrelations of Tests and Criterion

(N = 39 Boys in the Experiment)

	Otis, I.Q.	Teachers' * Estimates	Wiggly Block	Finger Dexterity	Tweezer Dexterity	MacQuarrie	Spatial Relations (Time)	Spatial Relations (Errors)	Kent Shakow	Detroit	Manipulation (Placing)	Manipulation (Turning)	Assembly
Otis, I.Q.		.54	.46	.35	.48	.45	.57	.49	.51	.65	.47	.48	.52
Teachers' Estimate	.54		*.51	.64	.72	.53	.69	.75	.68	.56	.66	.79	.74
*Wiggly Block	.46	*.51		.48	.53	.24	.55	.52	.56	.27	.48	.52	*.57
Finger Dexterity	.35	.64	.48		.84	.51	.67	.72	.74	.55	.72	.54	.60
Tweezer Dexterity	.48	.72	.53	.84		.50	.81	.84	.80	.58	.73	.70	.64
MacQuarrie	.45	.53	.24	.51	.50		.70	.64	.58	.73	.65	.55	.55
Spatial Relations (Time)	.57	.69	.55	.67	.81	.70		.80	.79	.76	.83	.90	.80
Spatial Relations (Errors)	.49	.75	.52	.72	.84	.64	.80		.76	.56	.62	.71	.75
Kent Shakow	.51	.68	.56	.74	.80	.58	.79	.76		.49	.63	.62	.81
Detroit	.65	.56	.27	.55	.58	.73	.76	.56	.49		.62	.44	.56
Manipulation (Placing)	.47	.66	.48	.72	.73	.65	.83	.62	.63	.62		.88	.56
Manipulation (Turning)	.48	.79	.52	.54	.70	.55	.90	.71	.62	.44	.88		.64
Minnesota Assembly	.52	.74	*.57	.60	.64	.55	.80	.75	.81	.56	.56	.64	

*Corrected correlations

Wiggly Block and Teachers' Estimates .68
Wiggly Block and Minnesota Assembly .73

> using college aptitude examinations which generally give correlations of between +.45 and +.55 with subsequent scholastic success. It is fair to assume that a mechanical ability test giving a correlation of +.50 or more with the criterion, would be as useful in connection with vocational courses as most intelligence tests in connection with academic work.

Bearing this in mind it is reasonably safe to accept justifiably a validity correlation coefficient of .50 or higher in this experiment.

(3) Summary of Data--Below follows in turn, a summary of the results of each test:

(a) The Wiggly Block--This is a performance test designed primarily as a measure of ability to visualize structure in three dimensions. A glance at Table VIII shows that it had a correlation of .46 with the Otis I.Q. indicating that a certain amount of intelligence is required to speedily assemble these blocks. With the criterion the original correlation (refer to Table VIII for all correlations) was .51. Upon investigation it was seen that one subject showed a complete negative relationship. Table XXI shows this freakish situation. A new correlation was computed without this oddity and the new measure yielded a correlation of .68, an increase of .17 over the original. As it is permissible in testing to eliminate situations that do not affect the prognostic value of

a test, the corrected correlation of .68 was accepted over the original. This revision gave the Wiggly Block final consideration in the ultimate battery because it also showed low correlations with all the tests except the Assembly Test. Notably low were the correlations with the MacQuarrie Test (.24), the Detroit Test (.27), Finger Dexterity (.48) and the Manipulation Placing Test (.48).

(b) The Finger Dexterity Test--This performance test was designed to measure the speed of fingers in work requiring eye-hand coordination. It yielded a relationship of .64 with the criterion and .48 with the Wiggly Block which was indication enough that it measured something different from the former. However, it correlated highly with the other tests notably the Tweezer Dexterity where the correlation was .84. This obviously indicated that these tests measured like traits.

(c) Tweezer Dexterity Test--This is another apparatus type of test which is designed to measure skill and speed in manipulating small tools in work requiring fine eye-hand coordination. Its relationship of .72 with the criterion seemed an indication that it ought to have been considered in the final battery but the surprisingly high correlations of .53, .84, .50, .81, .64, .70, .54, .73, .70, .64 with the other measures made it necessary to eliminate it in the final reckoning.

(d) Macquarrie Test for Mechanical Ability--This is a paper-and-pencil performance test designed to measure eye-hand coordination, speed of movement and ability to deal with spatial relationships. It seemed advisable at the outset to include at least two paper-and-pencil tests. The Macquarrie Test was one of these and well chosen it was because its validity coefficient was .53 and its correlation with the Wiggly Block and Finger Dexterity were sufficiently low (.24 and .51 respectively) to warrant final consideration.

(e) Minnesota Spatial Relations Boards A and B--This apparatus test directly measures the speed required in discriminating odd sizes and shapes and indirectly the ability to visualize two-dimensional relationships. Of interest is the scoring of the test which yields two sets of scores, one, a time score the other, a motor reaction score called the error score. These two scores seemed acceptable from the standpoint of their criterion relationship but they yielded unusually high measures with the other tests making it necessary to reject this test in the final analysis. The relationships between this test and others follows:

	Spatial Relations (Time)	Spatial Relations (Errors)
Criterion	.69	.75
Wiggly Block	.55	.52
Finger Dexterity	.67	.72
MacQuarrie	.70	.64
Kent Shakow	.79	.76
Detroit	.76	.56
Manipulation (Placing)	.63	.62
Manipulation (Turning)	.90	.71
Assembly	.80	.75
Tweezer Dexterity	.81	.84
Spatial Relations (Time)		.80
Spatial Relations (Errors)	.80	

(f) Kent Shakow Form Boards, Simple Tasks--Although originaly designed to measure mechanical aptitudes of mental hospital patients, this test now appears to be an excellent test in discriminating relationships in two dimensions. It gave the significant correlation of .68 with the Teachers' Estimates but here again it must be disregarded because of its high relationships with the other measures.

(g) Revised Detroit Mechanical Aptitude Examination, Form A--This revision was published in 1939. It is a paper-and-pencil verbal test and as such involves intelligence. This was verified in that it gave a correlation of .65 with the Otis I.Q. Its relationships of .56 with the criterion and .27 with the Wiggly Block seemed to warrant its consideration in the final battery. However, it yielded a correlation of .73 with the other paper-and-pencil test, the MacQuarrie

Test, indicating that one or the other must be disregarded. As the MacQuarrie obviously better fulfilled the requisites for final consideration the omission of the Detroit was necessary.

(h) Minnesota Rate of Manipulation--This apparatus consists of two tests, the placing test designed to measure skill and speed in hand manipulation and the turning test skill and speed in finger manipulation requiring eye-hand coordination. Here were their relationships with other measures:

	Placing	Turning
Criterion	.66	.79
Wiggly Block	.46	.52
Finger Dexterity	.72	.54
Tweezer Dexterity	.73	.70
MacQuarrie	.65	.55
Spatial Relations (Time)	.83	.90
Spatial Relations (Errors)	.62	.71
Kent Shakow	.63	.62
Detroit	.62	.44
Assembly	.56	.64
Manipulation (Placing)		.88
Manipulation (Turning)	.88	

Relationships with the criterion were excellent but relationships with other tests indicated the measurement of similar aptitudes. Note the unusually high correlations with the Spatial Relations (Time) test. Of significance also was the .88 correlation between the two forms of the test indicating an apparent measure of like skills.

(i) Minnesota Mechanical Assembly Test Box B--This apparatus was designed to measure the ability to recognize and assemble mechanical devices. In spite of its correlation of .74 with the criterion it had to be disregarded because of its similarity with all other measures. The elimination of an undesirable unit in the Wiggly Block-Assembly correlation gave a corrected relationship of .73. (See Table XII).

(4) Final Battery of Tests--Now came the task to determine which of the tests of the preliminary series were worthy to be retained in the final aptitude battery. This selection was done on the basis of correlation coefficients. The fact to remember was that "the correlation between the tests and the criterion should be as large as possible whereas the correlations among the tests should be as small as possible".

A glance at Table VIII shows that all relationships with the criterion were sufficiently high to warrant consideration. The next thing was to examine the correlations among the tests to see whether the relationships were sufficiently small to satisfy the second requisite of the prime considerations. A preliminary examination showed the following low coefficients:

Wiggly Block:
Finger Dexterity .48
MacQuarrie .24
Detroit .27
Manipulation (Placing) .48

Finger Dexterity:
Wiggly Block .48
MacQuarrie .51

Tweezer Dexterity:
MacQuarrie .50

MacQuarrie:
Wiggly Block .24
Finger Dexterity .51
Tweezer Dexterity .50

Both Spatial Relations Tests showed no correlation below .50 and had therefore to be eliminated.

Kent Shakow:
Detroit .49

Detroit:
Wiggly Block .27
Kent Shakow .49
Manipulation (Turning) .44

The Assembly Test showed too high relationships to be further considered.

This analysis narrowed the problem down to eight possibilities with the combinations shown below:

No.	Tests	1	2	3	4	5	6	7	8
1	Wiggly Block		.48		.24		.27	.46	
2	Finger Dexterity	.48			.51				
3	Tweezer Dexterity				.50				
4	MacQuarrie	.24	.51	.50					
5	Kent Shakow						.49		
6	Detroit	.27				.49			.44
7	Manipulation (Placing)	.48							
8	Manipulation (Turning)						.44		

Of this number only three had intercorrelations that were low. This is indicated here:

No.	Tests	1	2	3
1	Wiggly Block		.48	.24
2	Finger Dexterity	.48		.51
3	MacQuarrie	.24	.51	

Passing to the others it was found that Tweezer Dexterity correlated thusly with these three:

Wiggly Block	.53
Finger Dexterity	.84
MacQuarrie	.50

The correlation of .84 with the Finger Dexterity was so high as to warrant rejecting it in favor of Finger Dexterity which better fulfilled other requisites.

The Kent Shakow was likewise rejected because of its following relationships:

Wiggly Block	.56
Finger Dexterity	.74
MacQuarrie	.58

At first glance the Detroit Test seemed to be another possibility because of its .27 relationship with the Wiggly Block and .55 with the Finger Dexterity, but its surprisingly high correlation with the MacQuarrie (.73) made it inadvisable to include it in the final battery.

The Manipulating Placing Test was immediately disregarded but the Turning Test offered consideration:

Wiggly Block	.52
Finger Dexterity	.54
MacQuarrie	.55

However, it seemed advisable also, to eliminate this test to keep the administration time to within an hour. Furthermore, skills measured by this test were included in the Finger Dexterity and MacQuarrie Tests as evidenced by the correlations of .54 and .55 respectively.

As the result of the analysis, then, the final choice remained as follows:

Wiggly Block
Finger Dexterity
MacQuarrie

Using the multiple correlation technique, this battery yielded a composite correlation coefficient of .82 with the criterion, an unusually high validity coefficient.

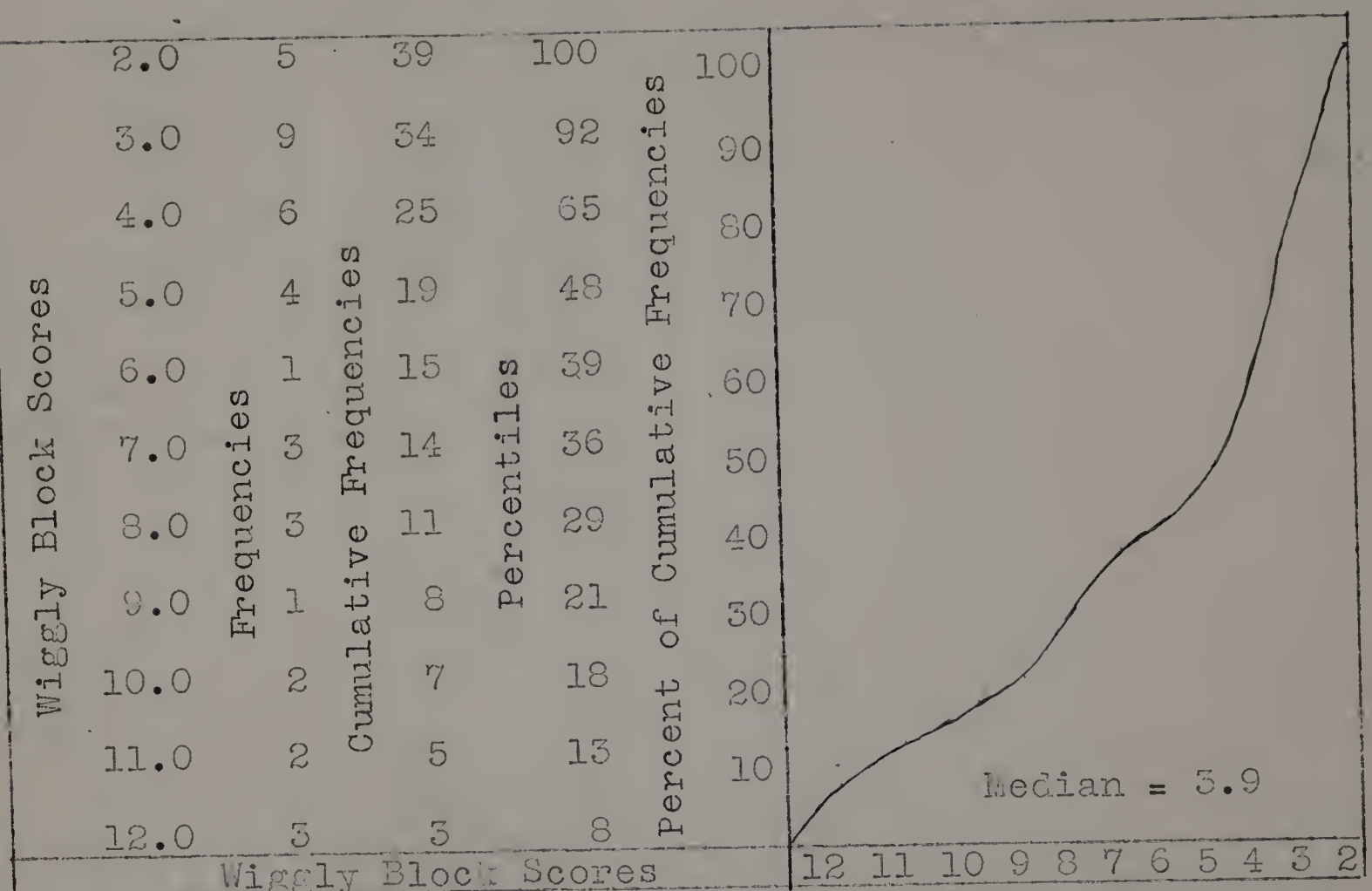

Figure 4

Ogive curve showing the percentile ratings in the Wiggly Block Test.

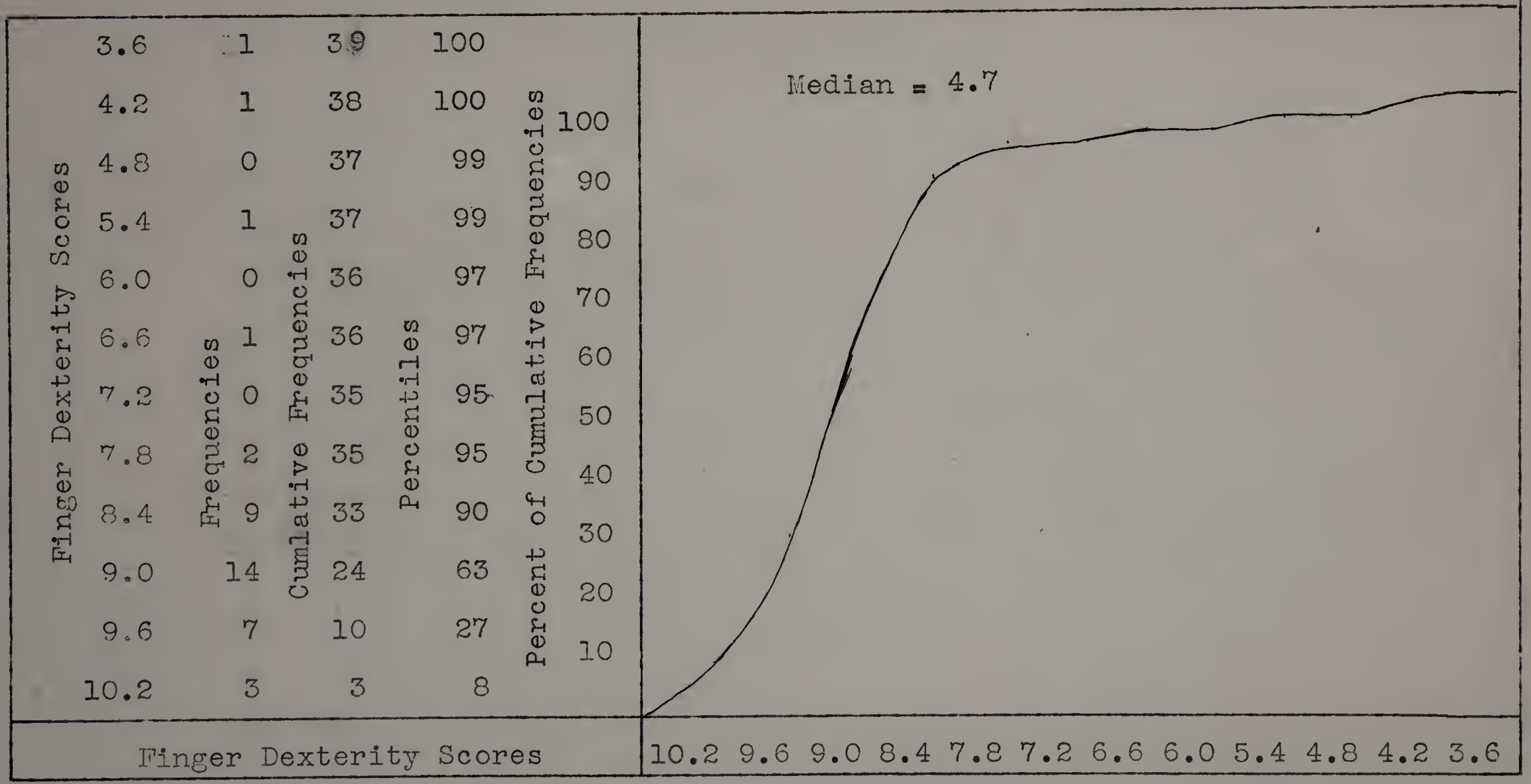

Figure 5

Ogive curve showing the percentile ratings in the Finger Dexterity Test.

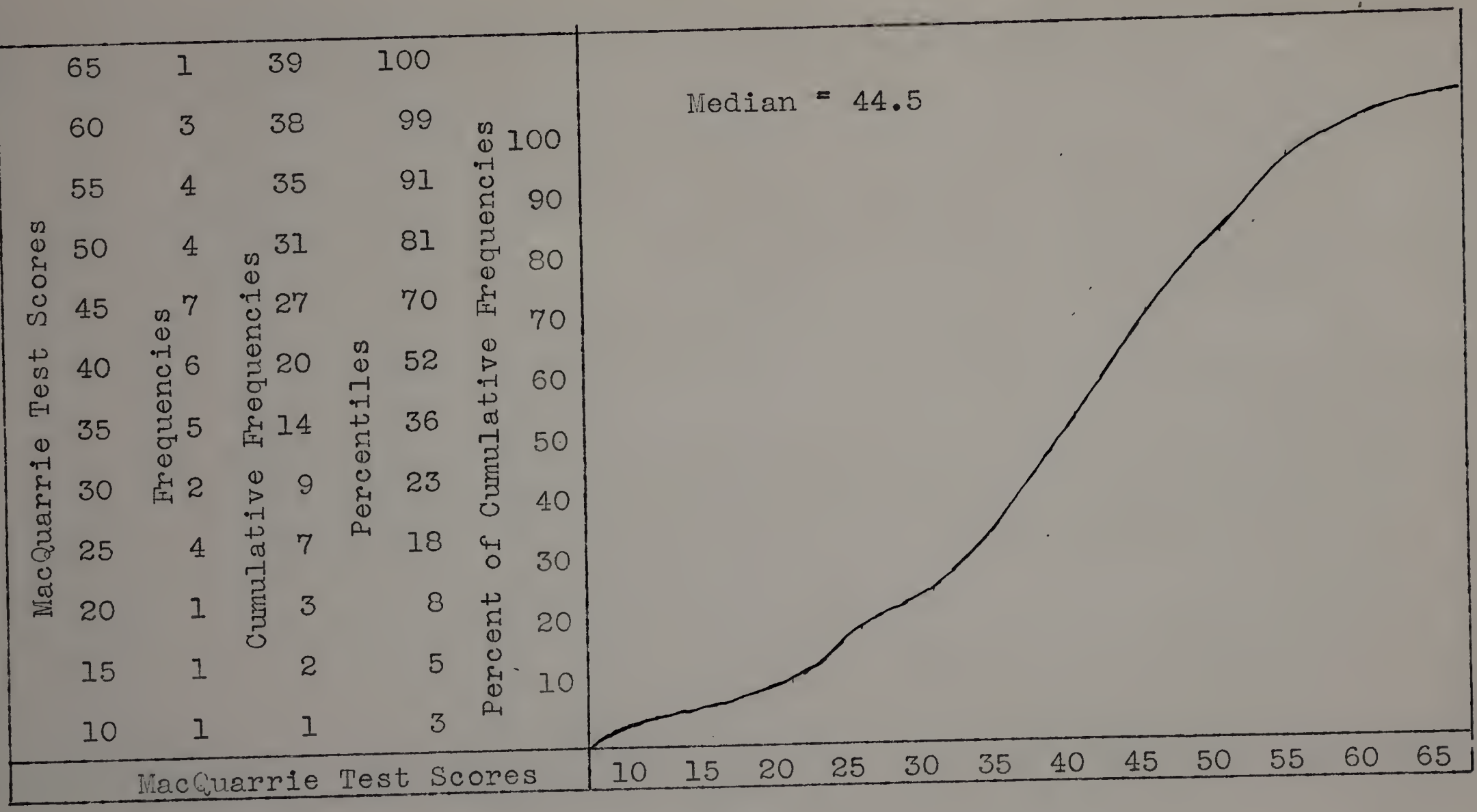

Figure 6

Ogive curve showing the percentile ratings in the MacQuarrie Test.

Percentile norms are included for each of these three tests in Figures 4, 5 and 6 respectively. In spite of the small number of subjects from which these norms were computed it is hoped that they will be of value in further research with regards to testing the feeble-minded for mechanical aptitude.

CONCLUSIONS

Chapter V

Conclusions

(1) Significance of Results--As concerns mechanical ability among the feeble-minded as measured in this experiment the following concluding statements may be made:

(a) A battery of mechanical aptitude tests was developed which, from the standpoint of validity, constitutes an adequate measure of mechanical ability as regards the mentally deficient. Of the eleven tests tried out in the experiment, three fulfilled the established conditions to justify their choice as a suitable final battery. These conditions were that:

1. They correlate as high as possible with the criterion.

2. They correlate as low as possible with each other.

The three tests that most satisfactorily met these conditions were as follows:

	Criterion	Wiggly Block	Finger Dexterity	MacQuarrie
Wiggly Block	.68		.48	.24
Finger Dexterity	.64	.48	.51	
MacQuarrie	.53	.24	.51	

A multiple correlation of these three tests with the criterion yielded the unusually high validity coefficient of .82.

(b) Of significance was the discovery that mechanical ability among the feeble-minded involves some little intelligence as indicated by the relatively high positive correlations between those tests and intelligence:

Otis I.Q. and -	
Wiggly Block	.46
Finger Dexterity	.35
MacQuarrie	.45

(c) A close correspondence was found between mechanical ability and the degree of feeble-mindedness. The experiment showed that very little mechanical ability is present in the degrees lower than borderline and moron subjects. This seems to indicate a mental age level of nine as an approximate basis.

(2) Prediction of Mechanical Ability among the Feeble-Minded--This study presented evidence on the prediction of mechanical ability of the feeble-minded. This was brought out in the experiment by the administration of a battery of tests to a group of feeble-minded and appraised in relation to a carefully determined criterion.

This experiment ought to be of valuable assistance to counselors in estimating a feeble-minded boy's mechanical aptitudes and clarifying the mistake of immediately placing a boy of low intellectual grade without mechanical ability into an industrial course.

It is recognized that manual skills of one sort or another are a prerequisite to succeed in manual occupations. These skills, however slight they may be in the feeble-minded, can be recognized as evidenced in this investigation. The study also brought out the fact that mechanical skills may be manifested to a high degree among the feeble-mineded. Better training of these skills may go a long way towards the better adjustment of the feeble-minded in the community.

APPENDIX I

APPENDIX 1

Description of the Tests in the Experiment

The Wiggly Blocks by Johnson O'Connor.[1]

Description--This intriguing mechanical puzzle consists of nine wooden blocks of irregularly wavy contour. When properly assembled they fit together to make a solid rectangular block. The speed with which this is done is taken as a measure of ability to visualize structure in three dimensions, an ability indicative of aptitude for such occupations as machinist, tool and die maker, draftsman, engineer, and architect.

Publisher--J. O'Connor, Stevens Institute of Technology, Hoboken, New Jersey.

Finger Dexterity Test, 1928, by Johnson O'Connor.[2]

Description--This apparatus consists of a metal plate in which 100 holes, each large enough to hold three small metal pins, are drilled. The individual picks up three pins at a time from the shallow tray attached to the plate, and places them in the holes as fast as he can. The score is a measure of the speed with which an individual can use his fingers in work requiring fine eye-hand coordination.

The time required for the test varies, but 15 minutes are usually ample.

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(1) Walter Van Dyke Bingham, Aptitudes and Aptitude Testing, p. 312. New York: Harper and Brothers, 1937. pp. viii and 390.

(2) Donald G. Paterson, Gwendolen G. Schneidler and Edmund G. Williamson, Student Guidance Techniques, p. 255. New York: McGraw-Hill Book Company, Inc., 1938, pp. xviii and 316.

Publisher and Cost--J. O'Connor, Stevens Institute of Technology, Hoboken, New Jersey. Price, board for finger and tweezer tests with pins, for $20.

Tweezer Dexterity Test, 1928, by Johnson O'Connor.[3]

Description--The apparatus for this test is the same as that for the finger dexterity test, except that the reverse of the metal board, in which are drilled 100 holes, each large enough to hold one small metal pin, is used. The tray holds the pins, which are picked up one at a time with a pair of tweezers and placed in the holes as fast as possible. The score is a measure of the skill and speed with which the person is able to manipulate a small tool in work requiring fine eye-hand coordination. Rarely is more than 10 minutes needed for administration.

Publisher and Cost--Johnson O'Connor, Stevens Institute of Technology, Hoboken, New Jersey. Price, board for finger and tweezer tests, with pins for $20. The Department of Mechanical Engineering at the University of Minnesota, Minneapolis, will also supply the test on order.

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(3) Donald G. Paterson, Gwendolen G. Schneidler and Edmund G. Williamson, Op. cit., p. 237.

MacQuarrie Test for Mechanical Ability by T. W. MacQuarrie.[4]

Description--This is a paper-and-pencil test which can be administered to an individual or to a group in about half an hour.

There are seven sub-tests, each preceded by a fore-exercise to familiarize the candidate with the tasks expected of him. These tasks are: to draw a pencil line as fast as possible through a pattern of irregularly spaced openings without touching them (thirty seconds); to put three pencil dots in each of a number of circles as fast as possible (thirty seconds); to put a dot in each of many smaller circles (thirty seconds); to copy patterns each of which consists of four connected straight lines (two and a half minutes); to identify the locations of dots in squares by reference to the corresponding positions of letters in a larger square (two minutes); to count the blocks which touch certain blocks in each of several pictured piles (two and a half minutes); and to follow with the eye, one after another, each of several numbered lines drawn irregularly through a maze-like pattern, and to identify by means of the appropriate number the end of each line (two and a half minutes.

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(4) Walter Van Dyke Bingham, Op. cit., p. 314-315.

Publisher and Cost--Research Service Company, 4529 South Van Buren Place, Los Angeles, California; The Psychological Corporation, 522 Fifth Ave., New York. Prices: tests, including directions, keys and norms, 25 copies for $1.50; sample set for $0.15.

Minnesota Spatial Relations Tests, 1930, by D. G. Paterson, R. M. Elliott, L. D. Anderson, H. A. Toops and E. Heidbreder.[5]

Description--This test is a revision of Link's Spatial Relations test. The equipment consists of four boards with 58 odd-shaped cutouts. There are two sets of blocks, one for boards A and B and another for boards C and D. The blocks for each board are placed in a definite order before the examinee and he is instructed to place them in their proper places in the board as rapidly as possible. The score is the amount of time required to replace the blocks in the four boards. Thus, the test measures directly the speed with which one can discriminate odd sizes and shapes and indirectly "mechanical aptitude."

Publisher and Cost--Marietta Apparatus Company, Marietta, Ohio. Price, set of equipment for $34.

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(5) Donald G. Paterson, Gwendolen G. Schneidler and Edmund G. Williamson, Op. cit., p. 225.

Kent-Shakow Form Boards, 1928, by Grace Kent and D. Shakow.[6]

Description--The industrial model of the Kent-Shakow revision of the Worcester Form Board Series is a wooden frame 22 inches long by 10 inches wide with 5 recesses of slightly different shapes. There are 7 different sets of blocks with which the recesses may be filled, and each of the sets constitutes a different task for the examinee. Each task is presented 5 times because of the 5 recesses of slightly altered shape. For example, the first task (2S) involves fitting each of the 5 recesses with 2 blocks which are cut on the straight line and divided in the same way. For the second task (2D), the examinee fits each of the 5 recesses with a different set of blocks which are cut on the diagonal. The number of blocks in each recess is still 2 for this task. In the third task (3S) 3 straight-cut blocks are placed in each recess. In the fourth task, (3D) 3 diagonally cut blocks are required to fill each recess. Likewise, for the fifth task (4S), each recess requires 4 straight-cut blocks; for the sixth (4D), 4 diagonally cut blocks; for the seventh (4DD), 4 other diagonally cut blocks; and for the eighth (5D), 5 diagonally cut blocks.

For each task the set of blocks is arranged in a random order and the score is the time in seconds required to fill the 5 recesses.

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(6) Donald G. Paterson, Gwendolen G. Schneidler and Edmund G. Williamson, Op. cit., p. 229-230.

Publisher and Cost--C. H. Stoelting Company, 424 North Homan Ave., Chicago, Illinois. Price, $60 for industrial model. Recent information indicates sharp advance in price. These boards are also made on order by Mr. Sven G. Nilsson, 16 Maverick Rd., Worcester, Mass., for $45.

Detroit Mechanical Aptitudes Examination, Form A, 1939, by Harry J. Baker, Paul H. Voelker, and Alex C. Crockett.[7]

Description--This is a paper and pencil test and it may be administered to both boys and girls at the same time. The former editions made it necessary to administer these two groups separately.

Some of the difficulties of understanding the directions and procedure of the earlier forms have been corrected. Page number 1 has been arranged in a more convenient form with multiple-choice answers. Many of the items appeal to the interest of girls as well as boys and make the test suitable for both groups.

The new test number 2 of motor speed and precision causes less emotional excitement than the former test of tracing in lanes of various width and is somewhat easier to score.

The time limit of test 3 has been increased from 3 to 4 minutes.

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(7) Harry J. Baker, Paul H. Voelker, and Alex C. Crockett, Detroit Mechanical Aptitudes Examination, Form A, 1939, Manual of Directions. Illinois: Public School Publishing Company.

Test 4 of arithmetic is a new departure in the present edition but is an important element in mechanical aptitude.

Test number 5 of disarranged pictures is designated to replace the old test number 4. It contains items of interest to both boys and girls.

Test number 7 replaces the old pulleys test of the edition for boys and the sewing test in the earlier edition for girls. The situations have been simplified and instruction is given in the principles upon which the pulleys operate.

Test number 8 replaces the former test number 5. It has increased the number of different items from 4 to 8 and lengthened the time limits. It eliminates the emotional phases of the more novel situations formerly found in test number 5.

In general the examination as a whole is easier to understand and more interesting than the earlier edition. The new pages have been selected from parts of the Detroit General Aptitudes Examination. Norms have been established on 10,000 pupils, mostly unselected distributions from the eighth and ninth grades. These have been supplemented by sample testing of small groups from higher and lower grades ranging from special classes of mentally handicapped children to high-school graduating classes.

Publisher and Cost--Public School Publishing Company, Bloomington, Illinois. Prices: Revised Detroit Mechanical Aptitudes Examination, Form A; $3.00 per 100 copies or 4¢ each in smaller quantities, plus postage. Two Manuals of Directions (10¢ each), two Answer Sheets (1¢ each), and four Class Record Sheets (1¢ each) are furnished free with each 100 tests. Sample set, 15¢.

Minnesota Rate of Manipulation or Minnesota Manual Dexterity Test, 1931, by W. A. Ziegler.[8]

Description--The apparatus for this test consists of a board measuring 39½ inches by 10¼ inches (see references for exact dimensions). There are 4 rows of 58 round holes in the board. The blocks, which fit easily into these holes, are placed in a regular order beyond the board and the examinee is instructed to replace the blocks in the board in a specified manner and as quickly as possible. Four trials are allowed and the time for each recorded.

A second task, called the Turning Test, was devised. For this group of four trials the blocks are presented in their positions in the board. The examinee is instructed to start at one end of the board and to turn each block over by lifting with one hand and replacing with the other until all 58 blocks have been turned. The two parts

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(8) Donald G. Paterson, Gwendolen G. Schneidler and Edmund G. Williamson, Student Guidance Techniques, p. 240. New York: McGraw-Hill Book Company, Inc., 1938, pp. xviii and 316.

measure speed of arm and hand movements in picking up and placing blocks in uniform holes. The entire test usually requires less than 10 minutes.

Publisher and Cost--Mechanical Engineering Department, University of Minnesota, Minneapolis, Minnesota. Price, $6.50 per set of original apparatus. Educational Test Bureau, 720 Washington Ave. S.E., Minneapolis, Minnesota. Price, $6.50 per set of apparatus. This apparatus is a slight revision of the original.

Minnesota Mechanical Assembly Test, 1930, by D. G. Paterson, R. M. Elliott, L. D. Anderson, H. A. Toops and E. Heidbreder.[9]

Description--The apparatus consists of three boxes with several compartments each containing parts, which, when correctly assembled, form simple mechanical objects. It is a revision of the J. L. Stenquist Mechanical Assembly Test. Time limits have been established for each object, but this allotment is usually ample and the test actually measures the ability to recognize and assemble these devices, rather than speed of performance. A certain number of points is given for each perfect assemblage and partial credits are given when parts of an object are correctly assembled. When the full time allowed is needed, the complete test requires about an hour.

Publisher and Cost--Marietta Apparatus Company, Marietta, Ohio. Price, the set of three boxes for $29.

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(9) Donald G. Paterson, Gwendolen G. Schneidler and Edmund G. Williamson, Op. cit., p. 222.

APPENDIX II

Table IX Scatter Diagram Showing the Correlation Between Otis I.Q. and Teachers' Estimate.

Otis I.Q.	Teachers' Estimates													
				13 7	20 14	27 21	34 28	41 35	48 42	55 49	62 56	69 63	76 70	83 77
80 78											1	2	1	
77 75									1		1	1	1	
74 72											1	1		1
71 69											1	1		1
68 66									2			1		
65 63										3		2		
62 60										3	1	2	1	
59 57							1		1	1				1
56 54								1		2	1			
53 51								1						
50 48				1										

r = .54

Table X Scatter Diagram Showing the Correlation Between Otis I.Q. and Wiggly Block

Otis I.Q.	Wiggly Block 12 11.1	11 10.1	10 9.1	9 8.1	8 7.1	7 6.1	6 5.1	5 4.1	4 3.1	3 2.1	2 1.1
80 78								1		3	
77 75									1	2	1
74 72		1							1		1
71 69	1									1	1
68 66			1						1	1	
65 63						1	1			2	1
62 60						2		3	2		
59 57		1	1		1						1
56 54	1			1	1				1		
53 51					1						
50 48	1										

r = .46

Table XI Scatter Diagram Showing the Correlation Between Otis I.Q. and Finger Dexterity

Otis I.Q.	Finger Dexterity												
			4	5	6	7	8	9	10	11	12	13	14	15
			10.2	9.6	9.0	8.4	7.8	7.2	6.6	6.0	5.4	4.8	4.2	3.6
			9.7	9.1	8.5	7.9	7.3	6.7	6.1	5.5	4.9	4.3	3.7	3.1
80 78											1	2	1	
77 75										1	1		2	
74 72												1	1	1
71 69											2	1		
68 66											1	1	1	
65 63										1	2	1	1	
62 60											2	4		1
59 57				1		1						2		
56 54								1				1	1	1
53 51												1		
50 48			1											

r = .35

Table XII Scatter Diagram Showing the Correlation Between Otis I.Q. and Tweezer Dexterity

Otis I.Q.	Tweezer Dexterity													
					16.1 17.0	15.1 16.0	14.1 15.0	13.1 14.0	12.1 13.0	11.1 12.0	10.1 11.0	9.1 10.0	8.1 9.0	7.1 8.0	6.1 7.0
80 78													1		3
77 75											1			1	2
74 72														1	2
71 69													2	1	
68 66														2	1
65 63												1	3	1	
62 60											1		1	3	2
59 57				1						1			1	1	
56 54										1					3
53 51									1						
50 48				1											

$r = .48$

Table XIII Scatter Diagram Showing the Correlation Between Otis I.Q. and MacQuarrie Test

Otis I.Q.	MacQuarrie Test												
			14 10	19 15	24 20	29 25	34 30	39 35	44 40	49 45	54 50	59 55	64 60	69 65
80 78									2		1		1	
77 75										1		2	1	
74 72										1	1			1
71 69						1	1					1		
68 66								1	2					
65 63					1	2		1		1				
62 60							1	1	1	2	1		1	
59 57				1				1	1		1			
56 54								1		2		1		
53 51						1								
50 48			1											

r = .45

Table XIV Scatter Diagram Showing the Correlation Between Otis I.Q. and Minnesota Spatial Relations (A & B Combined)

Otis I.Q.	Minnesota Spatial Relation (Time)													
					1350 1261	1260 1171	1170 1081	1080 991	990 901	900 811	810 721	720 631	630 541	540 451	450 361
80 78													1	2	1
77 75												2		1	1
74 72													1	1	1
71 69												2	1		
68 66												1	1	1	
65 63										1	2	1	1		
62 60											1	2	2	2	
59 57							1	1					1	1	
56 54											2			2	
53 51					1										
50 48					1										

r = .57

Table XV Scatter Diagram Showing the Correlation Between Otis I.Q. and Spatial Relations (Errors)

Otis I.Q.	Spatial Relations (Errors) 61 65	56 60	51 55	46 50	41 45	36 40	31 35	26 30	21 25	16 20	11 15	6 10
80 78									2	1	1	
77 75								1		2	1	
74 72									1	2		
71 69							1	1		1		
68 66						1				1	1	
65 63							2	3				
62 60							2	1	2	2		
59 57			1				1			1		1
56 54					1	1				2		
53 51					1							
50 48			1									

r = .49

Table XVI Scatter Diagram Showing the Correlation Between Otis I.Q. and Kent Shakow (Simple Tasks)

Otis I.Q.	Kent Shakow (Simple Tasks) 840 781	780 721	720 661	660 601	600 541	540 481	480 421	420 361	360 301	300 241	240 181	180 121	120 61
80 78										1		2	1
77 75									1	1	1	1	
74 72									1		1	1	
71 69										1	2		
68 66										3			
65 63							1			2	2		
62 60							1		3	1	1	1	
59 57			1					1		1		1	
56 54					1						1	2	
53 51						1							
50 48		1											

$r = .51$

Table XVII Scatter Diagram Showing the Correlation Between Otis I.Q. and Detroit

Otis I.Q.	Detroit 59 45	74 60	89 75	104 90	119 105	134 120	149 135	164 150	179 165	194 180	209 195	224 210
80 78							2			1	1	
77 75					1		2			1		
74 72							1			1		1
71 69				1		1	1					
68 66							2	1				
65 63			1		1	3						
62 60					1	1	4	1				
59 57			1	1	2							
56 54						1	2	1				
53 51		1										
50 48		1										

r = .65

Table XVIII Scatter Diagram Showing the Correlation Between Otis I.Q. Minnesota Manipulation (Placing)

Otis I.Q.	Minnesota Manipulation (Placing)														
	405 391	390 376	375 361	360 346	345 331	330 316	315 301	300 286	285 271	270 256	255 241	240 226	225 211	210 196
80 78										1		1	2	
77 75											2	1		1
74 72												2	1	
71 69											3			
68 66											1	1	1	
65 63										2	2	1		
62 60										2	1	4		
59 57		1								1	1		1	
56 54									1		1	1		1
53 51						1								
50 48	1													

r = .47

Table XIX Scatter Diagram Showing the Correlation Between Otis I.Q. and Minnesota Manipulation (Turning)

Otis I.Q.	Minnesota Manipulation (Turning) 570 541	540 511	510 481	480 451	450 421	420 391	390 361	360 331	330 301	300 271	270 241	240 211	210 181
80 78									1		2	1	
77 75									1		1	2	
74 72										1	2		
71 69										1	2		
68 66										2		1	
65 63										3	2		
62 60							1			2	4		
59 57						1				2		1	
56 54								2			1		1
53 51			1										
50 48		1											

r = .48

Table XX Scatter Diagram Showing the Correlation Between Otis I.Q. and Assembly

Otis I.Q.	Assembly													
			17 12	23 18	29 24	35 30	41 36	47 42	53 48	59 54	65 60	71 66	77 72	83 78
80 78										3			1	
77 75									1	1	1			1
74 72										1		1	1	
71 69									1		1		1	
68 66							1		1			1		
65 63								1	2		1	1		
62 60				1					2	1	2	1		
59 57				1		1			1			1		
56 54					1	1				1				1
53 51				1										
50 48			1											

r = .52

Table XXI Scatter Diagram Showing the Correlation Between Teachers' Estimate and Wiggly Block

Teachers' Estimates	Wiggly Block 12.0 11.1	11.0 10.1	10.0 9.1	9.0 8.1	8.0 7.1	7.0 6.1	6.0 5.1	5.0 4.1	4.0 3.1	3.0 2.1	2.0 1.1
83 77	1*										2
76 70								2			1
69 63								1	2	5	2
62 56		1			1				1	3	
55 49	1				1	3	1	1	1	1	
48 42		1	1						2		
41 35				1	1						
34 28			1								
27 21											
20 14											
13 7	1										

r = .51

* corrected r = .68

Table XXII Scatter Diagram Showing the Correlation Between Teachers' Estimate and Finger Dexterity

Teachers' Estimates	Finger Dexterity												
			10.2 9.7	9.6 9.1	9.0 8.5	8.4 7.9	7.8 7.3	7.2 6.7	6.6 6.1	6.0 5.5	5.4 4.9	4.8 4.3	4.2 3.7	3.6 3.1
83 77											1	1	1	
76 70											1	1		1
69 63											1	5	4	
62 56											1	2	2	1
55 49								1		1	4	3		
48 42						1				1	1	1		
41 35												1		1
34 28				1										
27 21														
20 14														
13 7			1											

r = .64

Table XXIII Scatter Diagram Showing the Correlation Between Teachers' Estimate and Tweezer Dexterity

Teachers' Estimates	Tweezer Dexterity 17.0 16.1	16.0 15.1	15.0 14.1	14.0 13.1	13.0 12.1	12.0 11.1	11.0 10.1	10.0 9.1	9.0 8.1	8.0 7.1	7.0 6.1
83 77									1	1	1
76 70										2	1
69 63									2	4	4
62 56									2	2	2
55 49							1	1	1	3	3
48 42							1	1		1	1
41 35						1					1
34 28				1							
27 21											
20 14											
13 7				1							

$r = .72$

Table XXIV Scatter Diagram Showing the Correlation Between Teachers' Estimates and MacQuarrie Test

Teachers' Estimates	MacQuarrie Test													
				14 10	19 15	24 20	29 25	34 30	39 35	44 40	49 45	54 50	59 55	64 60	69 65
83 77												1	1		1
76 70										1			1	1	
69 63						1	2		1	1	1	2		2	
62 56								1		1	2	1	1		
55 49							1	1	3	1	3				
48 42					1					2			1		
41 35							1				1				
34 28									1						
27 21															
20 14															
13 7				1											

r = .53

Table XXV Scatter Diagram Showing the Correlation Between Teachers' Estimate and Spatial Relations (Time) A and B

Teachers' Estimates	Spatial Relations (Time) A & B														
					1350 1261	1260 1171	1170 1081	1080 991	990 901	900 811	810 721	720 631	630 541	540 451	450 361
83 77												1		1	1
76 70												1	1	1	
69 63											1	3	1	4	1
62 56													3	2	1
55 49										1	3	1	3	1	
48 42						1						2		1	
41 35				1							1				
34 28							1								
27 21															
20 14															
13 7				1											

r = .69

Table XXVI Scatter Diagram Showing the Correlation Between Teachers' Estimate and Spatial Relations (Errors)

Teachers' Estimates	Spatial Relations (Errors)													
				65 61	60 56	55 51	50 46	45 41	40 36	35 31	30 26	25 21	20 16	15 11	10 6
83 77													2		1
76 70												1	2		
69 63										2	2		5	1	
62 56										1	1	2	1	1	
55 49								1		2	2	2	2		
48 42									1	1	1			1	
41 35								1	1						
34 28			1												
27 21															
20 14															
13 7			1												

r = .75

Table XXVII Scatter Diagram Showing the Correlation Between Teachers' Estimate and Kent Shakow (Simple Tasks)

Teachers' Estimates	Kent Shakow (Simple Tasks)														
		840 781	780 721	720 661	660 601	600 541	540 481	480 421	420 361	360 301	300 241	240 181	180 121	120 61
83 77												1	2	
76 70												2	1	
69 63											1	7	1	1	
62 56											1		1	3	1
55 49						1		2			2	1	2	1	
48 42									1		1	2			
41 35							1						1		
34 28				1											
27 21															
20 14															
13 7			1												

r = .68

Table XXVIII Scatter Diagram Showing the Correlation Between Teachers' Estimate and Detroit Test

Teachers' Estimates	Detroit Test														
				59 45	74 60	89 75	104 90	119 105	134 120	149 135	164 150	179 165	194 180	209 195	224 210
83 77							1		1						1
76 70								1		2					
69 63						1	1	2	1	1	1		2	1	
62 56								1	1	3			1		
55 49					1		2	2	4						
48 42					1					3					
41 35				1				1							
34 28						1									
27 21															
20 14															
13 7				1											

r = .56

Table XXIX Scatter Diagram Showing the Correlation Between Teachers' Estimates and Minnesota Manipulation (Placing)

Teachers' Estimates	Minnesota Manipulation (Placing)													
	405 391	390 376	375 361	360 346	345 331	330 316	315 301	300 286	285 271	270 256	255 241	240 226	225 211	210 196
83 77											1	1	1	
76 70											2		1	
69 63										1	2	3	3	1
62 56										1	2	2		1
55 49									1	3	3	2		
48 42		1									1	2		
41 35						1						1		
34 28										1				
27 21														
20 14														
13 7	1													

r = .66

Table XXX Scatter Diagram Showing the Correlation Between Teachers' Estimate and Minnesota Manipulation (Turning)

Teachers' Estimates	Minnesota Manipulation (Turning)														
		570 541	540	510 511	480	450 451	420 421	390 391	360 361	330 331	300 301	270 271	240 241	210 211	180 181
83 77											1	1	1		
76 70										1	1	1			
69 63											2	5	3		
62 56										1	2	1	1	1	
55 49								1	1		3	4			
48 42							1				1	2			
41 35			1						1						
34 28											1				
27 21															
20 14															
13 7		1													

r = .79

Table XXXI Scatter Diagram Showing the Correlation Between Teachers' Estimate and Assembly

Teachers' Estimates	Assembly														
				17 12	23 18	29 24	35 30	41 36	47 42	53 48	59 54	65 60	71 66	77 72	83 78
83 77													1	2	
76 70										1	1	1			
69 63										2	2	3	2	1	
62 56											3	1	1		1
55 49				1	1			1	5						1
48 42						1	1			1		1			
41 35				1		1									
34 28				1											
27 21															
20 14															
13 7			1												

$r = .74$

Table XXXII Scatter Diagram Showing the Correlation Between Wiggly Block and Finger Dexterity

Wiggly Block	Finger Dexterity													
			10.2 9.7	9.6 9.1	9.0 8.5	8.4 7.9	7.8 7.3	7.2 6.7	6.6 6.1	6.0 5.5	5.4 4.9	4.8 4.3	4.2 3.7	3.6 3.1
1.1 2.0											2	2	1	
2.1 3.0											2	2	5	
3.1 4.0										1	1	4		
4.1 5.0											1	2		1
5.1 6.0											1			
6.1 7.0										1	1	1		
7.1 8.0												2	1	
8.1 9.0														1
9.1 10.0				1								1		
10.1 11.0						1								1
11.1 12.0			1					1			1			

r = .48

Table XXXIII Scatter Diagram Showing the Correlation Between Wiggly Block and Tweezer Dexterity

Wiggly Block	Tweezer Dexterity													
					17.0 16.1	16.0 15.1	15.0 14.1	14.0 13.1	13.0 12.1	12.0 11.1	11.0 10.1	10.0 9.1	9.0 8.1	8.0 7.1	7.0 6.1
1.1 2.0													2	2	1
2.1 3.0													2	3	4
3.1 4.0											1		1	1	3
4.1 5.0														2	2
5.1 6.0													1		
6.1 7.0											1	1			1
7.1 8.0									1				1		1
8.1 9.0															1
9.1 10.0				1										1	
10.1 11.0										1				1	
11.1 12.0				1						1			1		

$r = .53$

Table XXXIV Scatter Diagram Showing the Correlation Between Wiggly Block and MacQuarrie Test

Wiggly Block	MacQuarrie Test												
			14 10	19 15	24 20	29 25	34 30	39 35	44 40	49 45	54 50	59 55	64 60	69 65
1.1 2.0					1	1					1	1		1
2.1 3.0						1	1	2	1	1	1		2	
3.1 4.0									2	1	2	1		
4.1 5.0									1	2			1	
5.1 6.0						1								
6.1 7.0							1	1		1				
7.1 8.0						1			1			1		
8.1 9.0										1				
9.1 10.0								1	1					
10.1 11.0				1						1				
11.1 12.0			1					1				1		

$r = .24$

Table XXXV Scatter Diagram Showing the Correlation Between Wiggly Block and Spatial Relations (Time)

Wiggly Block	Spatial Relations (Time)															
					1350 1261	1260 1171	1170 1081	1080 991	990 901	900 811	810 721	720 631	630 541	540 451	450 361
1.1 2.0												3		1	1
2.1 3.0										1	1		3	2	2
3.1 4.0												2		4	
4.1 5.0													2	2	
5.1 6.0											1				
6.1 7.0											1	1	1		
7.1 8.0				1									1	1	
8.1 9.0											1				
9.1 10.0								1				1			
10.1 11.0							1						1		
11.1 12.0				1							1	1			

$r = .55$

Table XXXVI Scatter Diagram Showing the Correlation Between Wiggly Block and Spatial Relations (Errors)

Wiggly Block	Spatial Relations (Errors) 61 65	56 60	51 55	46 50	41 45	36 40	31 35	26 30	21 25	16 20	11 15	6 10
1.1 2.0							1	1		2		1
2.1 3.0							2	1	1	3	2	
3.1 4.0							1	2		2	1	
4.1 5.0									2	2		
5.1 6.0								1				
6.1 7.0							1	1	1			
7.1 8.0						1				2		
8.1 9.0							1					
9.1 10.0			1				1					
10.1 11.0								1		1		
11.1 12.0			1			1					1	

r = .52

Table XXXVII Scatter Diagram Showing the Correlation Between Wiggly Block and Kent Shakow

Wiggly Block	Kent Shakow 840-781	780-721	720-661	660-601	600-541	540-481	480-421	420-361	360-301	300-241	240-181	180-121	120-61
1.1 2.0										2	1	2	
2.1 3.0										4	2	2	1
3.1 4.0									1	2	1	2	
4.1 5.0									2		1	1	
5.1 6.0						1							
6.1 7.0						1			1		1		
7.1 8.0					1					1		1	
8.1 9.0											1		
9.1 10.0				1						1			
10.1 11.0								1	1				
11.1 12.0		1			1						1		

r = .56

Table XXXVIII Scatter Diagram Showing the Correlation Between Wiggly Block and Detroit Test

Wiggly Block \ Detroit Test	45	60	75	90	105	120	135	150	165	180	195	210
1.1 2.0			1	2	1							1
2.1 3.0		1			2		2	1		2	1	
3.1 4.0						3	3					
4.1 5.0					1	1	2					
5.1 6.0					1							
6.1 7.0				1	1	1						
7.1 8.0	1			1			1					
8.1 9.0					1							
9.1 10.0			1				1					
10.1 11.0		1								1		
11.1 12.0	1					2						

$r = .27$

Table XXXIX Scatter Diagram Showing the Correlation Between Wiggly Block Minnesota Manipulation (Placing)

Wiggly Block	Minnesota Manipulation (Placing) 405 391	390 376	375 361	360 346	345 331	330 316	315 301	300 286	285 271	270 256	255 241	240 226	225 211	210 196
1.1 2.0											2	2	1	
2.1 3.0										2	3	1	2	1
3.1 4.0										1	1	3	1	
4.1 5.0											1	2	1	
5.1 6.0											1			
6.1 7.0										2		1		
7.1 8.0						1					1			1
8.1 9.0												1		
9.1 10.0										1	1			
10.1 11.0		1										1		
11.1 12.0	1									1		1		

r = .48

Table XI Scatter Diagram Showing the Correlation Between Wiggly Block and Minnesota Manipulation (Turning)

Wiggly Block	Minnesota Manipulation (Turning)													
	570 541	540 511	510 481	480 451	450 421	420 391	390 361	360 331	330 301	300 271	270 241	240 211	210 181
1.1 2.0									1		3	1	
2.1 3.0									1	3	1	4	
3.1 4.0										1	5		
4.1 5.0										1	3		
5.1 6.0											1		
6.1 7.0							1			1	1		
7.1 8.0			1							1			1
8.1 9.0									1				
9.1 10.0										2			
10.1 11.0							1			1			
11.1 12.0		1							1	1			

r = .52

Table XLI Scatter Diagram Showing the Correlation Between Wiggly Block and Assembly

Wiggly Block	Assembly													
			17 12	23 18	29 24	35 30	41 36	47 42	53 48	59 54	65 60	71 66	77 72	83 78
1.1 2.0									2		1	1	1	
2.1 3.0									2	2	2	1	1	1
3.1 4.0										1	1	3		1
4.1 5.0									1	2	1			
5.1 6.0								1						
6.1 7.0				1					2					
7.1 8.0				1					1	1				
8.1 9.0						1								
9.1 10.0				1			1							
10.1 11.0						1				1				
11.1 12.0			1		1								1*	

r = .57

* corrected r = .75

Table XLII Scatter Diagram Showing the Correlation Between Finger Dexterity and Tweezer Dexterity

Finger Dexterity	Tweezer Dexterity													
				17.0 16.1	16.0 15.1	15.0 14.1	14.0 13.1	13.0 12.1	12.0 11.1	11.0 10.1	10.0 9.1	9.0 8.1	8.0 7.1	7.0 6.1
3.1 3.6													2	1
3.7 4.2													2	5
4.3 4.8								1				3	5	5
4.9 5.4										1		5	1	2
5.5 6.0										1	1			
6.1 6.6														
6.7 7.2									1					
7.3 7.8														
7.9 8.4									1					
8.5 9.0														
9.1 9.6					1									
9.7 10.2					1									

$r = .84$

Table XLIII Scatter Diagram Showing the Correlation Between Finger Dexterity MacQuarrie Test

Finger Dexterity	MacQuarrie Test													
			10 14	15 19	20 24	25 29	30 34	35 39	40 44	45 49	50 54	55 59	60 64	65 69
3.1 3.6										2			1	
3.7 4.2						1		1		1	1	1	1	1
4.3 4.8					1	1	2		4	2	3		1	
4.9 5.4						2		2	2	1		2		
5.5 6.0										1		1		
6.1 6.6														
6.7 7.2								1						
7.3 7.8														
7.9 8.4				1										
8.5 9.0														
9.1 9.6								1						
9.7 10.2			1											

r = .51

Table XLIV Scatter Diagram Showing the Correlation Between Finger Dexterity and Spatial Relations (Time)

Finger Dexterity	Spatial Relations (Time)														
					1350 1261	1260 1171	1170 1081	1080 991	990 901	900 811	810 721	720 631	630 541	540 451	450 361
3.1 3.6											1		2		
3.7 4.2											1		1	2	3
4.3 4.8					1						1	3	2	7	
4.9 5.4										1	1	4	2	1	
5.5 6.0												1	1		
6.1 6.6															
6.7 7.2											1				
7.3 7.8															
7.9 8.4							1								
8.5 9.0															
9.1 9.6								1							
9.7 10.2				1											

r = .67

Table XLV Scatter Diagram Showing the Correlation Between Finger Dexterity and Spatial Relations (Errors)

Finger Dexterity	Spatial Relations (Errors)													
			61 65	56 60	51 55	46 50	41 45	36 40	31 35	26 30	21 25	16 20	11 15	6 10
3.1 3.6								1			1	1		
3.7 4.2									1			4	2	
4.3 4.8							1	1	1	3	2	5		1
4.9 5.4									3	1	2	2	1	
5.5 6.0										2				
6.1 6.6														
6.7 7.2							1							
7.3 7.8														
7.9 8.4									1					
8.5 9.0														
9.1 9.6			1											
9.7 10.2			1											

$r = .72$

Table XLVI Scatter Diagram Showing the Correlation Between Finger Dexterity and Kent Shakow

Finger Dexterity	Kent Shakow 840-781	780-721	720-661	660-601	600-541	540-481	480-421	420-361	360-301	300-241	240-181	180-121	120-61
3.1 3.6									1		2		
3.7 4.2										3		4	
4.3 4.8						1	1			1	5	2	4	
4.9 5.4							1			2	2	3		1
5.5 6.0										1		1		
6.1 6.6														
6.7 7.2					1									
7.3 7.8														
7.9 8.4								1						
8.5 9.0														
9.1 9.6			1											
9.7 10.2		1												

r = .74

Table XLVII Scatter Diagram Showing the Correlation Between Finger Dexterity and Detroit Test

Finger Dexterity	Detroit Test													
			59 45	74 60	89 75	104 90	119 105	134 120	149 135	164 150	179 165	194 180	209 195	224 210
3.1 3.6							1		1			1		
3.7 4.2							1		2	1		2		1
4.3 4.8			1			4	2	3	3				1	
4.9 5.4				1	1		2	3	2					
5.5 6.0							1		1					
6.1 6.6														
6.7 7.2								1						
7.3 7.8														
7.9 8.4				1										
8.5 9.0														
9.1 9.6					1									
9.7 10.2			1											

r = .55

Table XLVIII Scatter Diagram Showing the Correlation Between Finger Dexterity and Minnesota Manipulation (Placing)

Finger Dexterity	Minnesota Manipulation (Placing) 405-391	390-376	375-361	360-346	345-331	330-316	315-301	300-286	285-271	270-256	255-241	240-226	225-211	210-196
3.1 3.6											1	2		
3.7 4.2											2	2	1	2
4.3 4.8						1				1	4	4	4	
4.9 5.4										3	4	2		
5.5 6.0										1		1		
6.1 6.6														
6.7 7.2									1					
7.3 7.8														
7.9 8.4		1												
8.5 9.0														
9.1 9.6										1				
9.7 10.2	1													

r = .72

Table XLIX Scatter Diagram Showing the Correlation Between Finger Dexterity Minnesota Manipulation (Turning)

Finger Dexterity	Minnesota Manipulation (Turning)													
	570 541	540 511	510 481	480 451	450 421	420 391	390 361	360 331	330 301	300 271	270 241	240 211	210 181
3.1 3.6								1		2			
3.7 4.2										1	1	4	1
4.3 4.8			1							4	8	1	
4.9 5.4							1		2	2	4		
5.5 6.0										1	1		
6.1 6.6													
6.7 7.2								1					
7.3 7.8													
7.9 8.4							1						
8.5 9.0													
9.1 9.6										1			
9.7 10.2		1											

r = .54

Table L Scatter Diagram Showing the Correlation Between Finger Dexterity and Assembly

Finger Dexterity	Assembly														
				17 12	23 18	29 24	35 30	41 36	47 42	53 48	59 54	65 60	71 66	77 72	83 78
3.1 3.6							1				1	1			
3.7 4.2										1	1	1	1	2	1
4.3 4.8					2			1		1	3	3	3		1
4.9 5.4									1	5	1		1	1	
5.5 6.0										1	1				
6.1 6.6															
6.7 7.2						1									
7.3 7.8															
7.9 8.4							1								
8.5 9.0															
9.1 9.6					1										
9.7 10.2				1											

r = .60

Table II Scatter Diagram Showing the Correlation Between Tweezer Dexterity and MacQuarrie Test

Tweezer Dexterity	MacQuarrie Test														
			14 10	19 15	24 20	29 25	34 30	39 35	44 40	49 45	54 50	59 55	64 60	69 65
6.1 7.0							1		2	4	2	1	2	1
7.1 8.0						1	1	1	2	2	1	1	1	
8.1 9.0					1	2		1	2		1	1		
9.1 10.0										1				
10.1 11.0								1				1		
11.1 12.0				1				1						
12.1 13.0						1								
13.1 14.0														
14.1 15.0														
15.1 16.0														
16.1 17.0			1					1						

$r = .50$

Table LII Scatter Diagram Showing the Correlation Between Tweezer Dexterity and Spatial Relations (Time)

Tweezer Dexterity	Spatial Relations (Time) 1350–1261	1260–1171	1170–1081	1080–991	990–901	900–811	810–721	720–631	630–541	540–451	450–361
6.1 – 7.0							2		1	7	3
7.1 – 8.0							1	3	4	2	
8.1 – 9.0							1	1	3	2	1
9.1 – 10.0										1	
10.1 – 11.0									2		
11.1 – 12.0					1			1			
12.1 – 13.0			1								
13.1 – 14.0											
14.1 – 15.0											
15.1 – 16.0											
16.1 – 17.0			1			1					

$r = .81$

Table LIII Scatter Diagram Showing the Correlation Between Tweezer Dexterity and Spatial Relations (Errors)

Tweezer Dexterity	Spatial Relations (Errors) 61-65	56-60	51-55	46-50	41-45	36-40	31-35	26-30	21-25	16-20	11-15	6-10
6.1-7.0						1			3	6	3	
7.1-8.0						1	1	2	1	4		1
8.1-9.0							3	2	1	2		
9.1-10.0								1				
10.1-11.0							1	1				
11.1-12.0					1		1					
12.1-13.0					1							
13.1-14.0												
14.1-15.0												
15.1-16.0												
16.1-17.0			2									

r = .84

Table LIV Scatter Diagram Showing the Correlation Between Tweezer Dexterity and Kent Shakow

Tweezer Dexterity	Kent Shakow														
		840 781	780 721	720 661	660 601	600 541	540 481	480 421	420 361	360 301	300 241	240 181	180 121	120 61
6.1 7.0							1			1	3	2	6	
7.1 8.0										2	4	3	1	
8.1 9.0							1				3	2	1	1
9.1 10.0												1		
10.1 11.0										2				
11.1 12.0					1			1						
12.1 13.0						1								
13.1 14.0														
14.1 15.0														
15.1 16.0														
16.1 17.0		1	1											

$r = .80$

Table LV Scatter Diagram Showing the Correlation Between Tweezer Dexterity and Detroit Test

Tweezer Dexterity	Detroit Test														
				59 45	74 60	89 75	104 90	119 105	134 120	149 135	164 150	179 165	194 180	209 195	224 210
6.1 7.0							1	1	2	5			2	1	1
7.1 8.0							1	4	1	2	1		1		
8.1 9.0					1	1	2	1	2	1					
9.1 10.0								1							
10.1 11.0									1	1					
11.1 12.0					1				1						
12.1 13.0				1											
13.1 14.0															
14.1 15.0															
15.1 16.0															
16.1 17.0				1		1									

r = .58

Table LVI Scatter Diagram Showing the Correlation Between Tweezer Dexterity and Minnesota Manipulation (Placing)

Tweezer Dexterity	Minnesota Manipulation (Placing) 405-391	390-376	375-361	360-346	345-331	330-316	315-301	300-286	285-271	270-256	255-241	240-226	225-211	210-196
6.1 7.0											2	6	3	2
7.1 8.0										1	5	2	2	
8.1 9.0										2	4	2		
9.1 10.0										1				
10.1 11.0										1		1		
11.1 12.0		1							1					
12.1 13.0						1								
13.1 14.0														
14.1 15.0														
15.1 16.0														
16.1 17.0	1									1				

$r = .73$

Table LVII Scatter Diagram Showing the Correlation Between Tweezer Dexterity and Minnesota Manipulation (Turning)

Tweezer Dexterity	Minnesota Manipulation (Turning) 570 541	540 511	510 481	480 451	450 421	420 391	390 361	360 331	330 301	300 271	270 241	240 211	210 181
6.1 7.0								1			8	3	1
7.1 8.0									1	6	1	2	
8.1 9.0									1	3	4		
9.1 10.0										1			
10.1 11.0							1				1		
11.1 12.0						1		1					
12.1 13.0			1										
13.1 14.0													
14.1 15.0													
15.1 16.0													
16.1 17.0		1								1			

r = .70

Table LVIII Scatter Diagram Showing the Correlation Between Tweezer Dexterity Assembly

Tweezer Dexterity \ Assembly	17 12	23 18	29 24	35 30	41 36	47 42	53 48	59 54	65 60	71 66	77 72	83 78
6.1 7.0		1		1			1	3	1	2	2	2
7.1 8.0					1		2	2	3	2		
8.1 9.0						1	3	1	1	1	1	
9.1 10.0							1					
10.1 11.0							1	1				
11.1 12.0			1	1								
12.1 13.0		1										
13.1 14.0												
14.1 15.0												
15.1 16.0												
16.1 17.0	1	1										

r = .64

Table LIX Scatter Diagram Showing the Correlation Between MacQuarrie Test and Spatial Relations (Time)

MacQuarrie Test	Spatial Relations (Time)														
					1350 1261	1260 1171	1170 1081	1080 991	990 901	900 811	810 721	720 631	630 541	540 451	450 361
69 65															1
64 60													1	2	
59 55												3		1	
54 50														3	1
49 45											1		3	2	1
44 40												2	2	2	
39 35								1		1	1	1	1		
34 30											1		1		
29 25				1							2	1			
24 20												1			
19 15							1								
14 10				1											

$r = .70$

Table IX Scatter Diagram Showing the Correlation Between MacQuarrie Test and Spatial Relations (Errors)

MacQuarrie Test	Spatial Relations (Errors)													
				61 65	56 60	51 55	46 50	41 45	36 40	31 35	26 30	21 25	16 20	11 15	6 10
69 65													1		
64 60													3		
59 55											1		3		
54 50										1			1	1	1
49 45									1		1	2	2	1	
44 40									1		1	2	1	1	
39 35				1				1		2			1		
34 30											1	1			
29 25								1		2	1				
24 20											1				
19 15										1					
14 10				1											

$r = .64$

Table LXI Scatter Diagram Showing the Correlation Between MacQuarrie Test and Kent Shakow

MacQuarrie Test	Kent Shakow													
		840 781	780 721	720 661	660 601	600 541	540 481	480 421	420 361	360 301	300 241	240 181	180 121	120 61
69 65													1	
64 60											2	1		
59 55										1		2	1	
54 50												1	3	
49 45										3		2	2	
44 40											4		1	1
39 35			1		1					1	1	1		
34 30							1					1		
29 25						1	1				2			
24 20											1			
19 15								1						
14 10		1												

r = .58

Table LXII Scatter Diagram Showing the Correlation Between MacQuarrie Test and Detroit

MacQuarrie Test	Detroit														
				59 45	74 60	89 75	104 90	119 105	134 120	149 135	164 150	179 165	194 180	209 195	224 210
69 65															1
64 60										1			1	1	
59 55								1	1	2					
54 50							1		1	1			1		
49 45								3	2	1			1		
44 40							1		1	4					
39 35					1	1			2		1				
34 30							1	1							
29 25				1		1		2							
24 20							1								
19 15					1										
14 10				1											

$r = .75$

Table LXIII Scatter Diagram Showing the Correlation Between MacQuarrie Test and Minnesota Manipulation (Placing)

MacQuarrie Test	Minnesota Manipulation (Placing)														
	405 391	390	375 361	360 346	345 331	330 316	315 301	300 286	285 271	270 256	255 241	240 226	225 211	210 196
69 65												1		
64 60											1		1	1
59 55											2	1		1
54 50												2	2	
49 45										1	2	4		
44 40										2	2	1	1	
39 35									1	3			1	
34 30											1	1		
29 25						1					3			
24 20												1		
19 15		1												
14 10	1													

$r = .65$

Table LXIV Scatter Diagram Showing the Correlation Between MacQuarrie Test and Minnesota Manipulation (Turning)

MacQuarrie Test	Minnesota Manipulation (Turning)													
		570 541	540 511	510 481	480 451	450 421	420 391	390 361	360 331	330 301	300 271	270 241	240 211	210 181
69 65												1		
64 60											1	1	1	
59 55										1	1	1		1
54 50												2	2	
49 45									1		2	3	1	
44 40										1	3	2		
39 35								1	1		2		1	
34 30											1	1		
29 25			1								1	2		
24 20												1		
19 15							1							
14 10		1												

r = .55

Table LXV Scatter Diagram Showing the Correlation Between MacQuarrie Test and Assembly

MacQuarrie Test	Assembly														
				17 12	23 18	29 24	35 30	41 36	47 42	53 48	59 54	65 60	71 66	77 72	83 78
69 65														1	
64 60											1	2			
59 55										1	2			1	
54 50													3	1	
49 45							1			2	2				2
44 40								1		1	2	1	1		
39 35					1	1				3					
34 30					1							1			
29 25					1				1	1			1		
24 20												1			
19 15							1								
14 10				1											

$r = .55$

Table LXVI Scatter Diagram Showing the Correlation Between Spatial Relations (Time) and Spatial Relations (Errors)

Spatial Relations (Time)	Spatial Relations (Errors)													
				65 61	60 56	55 51	50 46	45 41	40 36	35 31	30 26	25 21	20 16	15 11	10 6
450 361													1	2	
540 451										1		1	6	1	1
630 541											2	3	3		
720 631									1	2	3		2		
810 721								1	1	1	1	1			
900 811										1					1
990 901															
1080 991			1												
1170 1081										1					
1260 1171															
1350 1261			1					1					1		

$r = .80$

Table LXVII Scatter Diagram Showing the Correlation Between Spatial Relations (Time) and Kent Shakow

Spatial Relations (Time)	Kent Shakow													
		840 781	780 721	720 661	660 601	600 541	540 481	480 421	420 361	360 301	300 241	240 181	180 121	120 61
361 450													3	
451 540										1	3	1	5	
541 630										2	2	3		1
631 720										2	4	2		
721 810					1		2				1	1		
811 900												1		
901 990														
991 1080			1											
1081 1170								1						
1171 1260														
1261 1350		1				1								

r = .79

Table LXVIII Scatter Diagram Showing the Correlation Between Spatial Relations (Time) and Detroit Test

Spatial Relations (Time)	Detroit Test													
			59 45	74 60	89 75	104 90	119 105	134 120	149 135	164 150	179 165	194 180	209 195	224 210
361 450									1			1		1
451 540						1	1	2	4			1	1	
541 630						1	2	1	2	1		1		
631 720					1	1	1	3	2					
721 810						1	3	1						
811 900				1										
901 990														
991 1080					1									
1081 1170				1										
1171 1260														
1261 1350			2											

$r = .76$

Table LXIX Scatter Diagram Showing the Correlation Between Spatial Relations (Time) and Minnesota Manipulation (Placing)

Spatial Relations (Time)	Minnesota Manipulation (Placing)														
	405 391	390 376	375 361	360 346	345 331	330 316	315 301	300 286	285 271	270 256	255 241	240 226	225 211	210 196
361 450											1	2		
451 540											1	3	4	2
541 630										2	3	2	1	
631 720										2	4	2		
721 810									1		2	2		
811 900										1				
901 990														
991 1080										1				
1081 1170		1												
1171 1260														
1261 1350	1					1								

$r = .83$

Table LXX Scatter Diagram Showing the Correlation Between Spatial Relations (Time) and Minnesota Manipulation (Turning)

Spatial Relations (Time)	Minnesota Manipulation (Turning)													
		570 541	540 511	510 481	480 451	450 421	420 391	390 361	360 331	330 301	300 271	270 241	240 211	210 181
361 450												1	2	
451 540												7	2	1
541 630										1	5	1	1	
631 720								1		1	3	3		
721 810									2		1	2		
811 900											1			
901 990														
991 1080											1			
1081 1170							1							
1171 1260														
1261 1350		1	1											

$r = .90$

Table LXXI Scatter Diagram Showing the Correlation Between Spatial Relations (Time) and Assembly

Spatial Relations (Time)	Assembly														
				17 12	23 18	29 24	35 30	41 36	47 42	53 48	59 54	65 60	71 66	77 72	83 78
361 450														2	1
451 540											4	1	4		1
541 630										4	2	2			
631 720								1		3	1	2		1	
721 810					1	1	1		1				1		
811 900										1					
901 990															
991 1080					1										
1081 1170							1								
1171 1260															
1261 1350				1	1										

$r = .80$

Table LXXII Scatter Diagram Showing the Correlation Between Spatial Relations (Errors) and Kent Shakow

Spatial Relations (Errors)	Kent Shakow														
		840 781	780 721	720 661	660 601	600 541	540 481	480 421	420 361	360 301	300 241	240 181	180 121	120 61
10 6													1	
15 11											1		2	
20 16										1	4	4	3	
25 21							1			2			1	1
30 26							1			1	2	2		
35 31								1		1	2	1	1	
40 36											1	1		
45 41					1	1								
50 46														
55 51														
60 56														
65 61		1	1											

$r = .76$

Table LXXIII Scatter Diagram Showing the Correlation Between Spatial Relations (Errors) and Detroit Test

Spatial Relations (Errors)	Detroit Test														
				59 45	74 60	89 75	104 90	119 105	134 120	149 135	164 150	179 165	194 180	209 195	224 210
6 10							1								
11 15										2			1		
16 20							1	2	2	3	1		1	1	1
21 25							1		1	2			1		
26 30							1	3	1	1					
31 35					2	1		1	2						
36 40								1		1					
41 45				1					1						
46 50															
51 55															
56 60															
61 65				1		1									

r = .56

Table LXXIV Scatter Diagram Showing the Correlation Between Spatial Relations (Errors) and Minnesota Manipulation (Placing)

Spatial Relations (Errors)	Minnesota Manipulation (Placing)														
	405 391	390 376	375 361	360 346	345 331	330 316	315 301	300 286	285 271	270 256	255 241	240 226	225 211	210 196
6 10													1	
11 15											1	2		
16 20											5	2	3	2
21 25										1		3	1	
26 30										2	2	2		
31 35		1								2	2	1		
36 40											1	1		
41 45						1			1					
46 50														
51 55														
56 60														
61 65	1									1				

$r = .62$

Table LXXV Scatter Diagram Showing the Correlation Between Spatial Relations (Errors) and Minnesota Manipulation (Turning)

Spatial Relations (Errors)	Minnesota Manipulation (Turning)													
		570 541	540 511	510 481	480 451	450 421	420 391	390 361	360 331	330 301	300 271	270 241	240 211	210 181
6 10													1	
11 15												1	2	
16 20										1	3	5	2	1
21 25										1	1	3		
26 30											3	3		
31 35							1	1			2	2		
36 40									1		1			
41 45			1						1					
46 50														
51 55														
56 60														
61 65		1									1			

r = .71

Table LXXVI Scatter Diagram Showing the Correlation Between Spatial Relations (Errors) and Assembly

Spatial Relations (Errors)	Assembly													
				17 12	23 18	29 24	35 30	41 36	47 42	53 48	59 54	65 60	71 66	77 72	83 78
6 10													1		
11 15													1	1	1
16 20										3	3	2	1	2	1
21 25					1					1	3				
26 30									1	1	1	3			
31 35							1			3			2		
36 40							1	1							
41 45					1	1									
46 50															
51 55															
56 60															
61 65				1	1										

$r = .75$

Table LXXVII Scatter Diagram Showing the Correlation Between Kent Shakow and Detroit Test

Kent Shakow	Detroit Test														
			45 59	60 74	75 89	90 104	105 119	120 134	135 149	150 164	165 179	180 194	195 209	210 224
61 120									1					
121 180						1		2	3			1		1
181 240				1			4	1	2					
241 300					1	2	1	1	2	1		1	1	
301 360							1	2	1			1		
361 420														
421 480				1										
481 540						1	1							
541 600			1											
601 660								1						
661 720														
721 780					1									
781 840			1											

$r = .49$

Table LXXVIII Scatter Diagram Showing the Correlation Between Kent Shakow and Minnesota Manipulation (Placing)

Kent Shakow	Minnesota Manipulation (Placing)													
	405-391	390-376	375-361	360-346	345-331	330-316	315-301	300-286	285-271	270-256	255-241	240-226	225-211	210-196
61-120										1				
121-180											2	3	2	1
181-240										2	4	1	1	
241-300										1	4	2	2	1
301-360										1		4		
361-420														
421-480		1												
481-540											1	1		
541-600						1								
601-660									1					
661-720														
721-780											1			
781-840	1													

r = .63

Table LXXIX Scatter Diagram Showing the Correlation Between Kent Shakow and Minnesota Manipulation (Turning)

Kent Shakow	Minnesota Manipulation (Turning)													
		570 541	540 511	510 481	480 451	450 421	420 391	390 361	360 331	330 301	300 271	270 241	240 211	210 181
61 120										1				
121 180												4	3	1
181 240									1	1	5	1		
241 300											4	4	2	
301 360								1			1	3		
361 420														
421 480							1							
481 540												2		
541 600			1											
601 660									1					
661 720														
721 780											1			
781 840		1												

r = .62

Table LXXX Scatter Diagram Showing the Correlation Between Kent Shakow and Assembly

Kent Shakow	Assembly													
			12 17	18 23	24 29	30 35	36 41	42 47	48 53	54 59	60 65	66 71	72 77	78 83
61 120										1				
121 180										2		2	2	2
181 240						1			3		2	1	1	
241 300							1		3	1	3	2		
301 360									2	3				
361 420														
421 480						1								
481 540				1				1						
541 600				1										
601 660					1									
661 720														
721 780				1										
781 840			1											

$r = .81$

Table LXXXI Scatter Diagram Showing the Correlation Between Detroit Test and Minnesota Manipulation (Placing)

Detroit	Minnesota Manipulation (Placing)													
	405-391	390-376	375-361	360-346	345-331	330-316	315-301	300-286	285-271	270-256	255-241	240-226	225-211	210-196
224-210												1		
209-195													1	
194-180												2		1
179-165														
164-150													1	
149-135										1	3	2	2	1
134-120									1	2	2	2		
119-105										1	4	2		
104-90											1	2	1	
89-75										1	1			
74-60		1								1				
59-45	1					1								

$r = .62$

Table LXXXII Scatter Diagram Showing the Correlation Between Detroit Test and Minnesota Manipulation (Turning)

Detroit	Minnesota Manipulation (Turning)													
	570 541	540 511	510 481	480 451	450 421	420 391	390 361	360 331	330 301	300 271	270 241	240 211	210 181
224 210											1		
209 195											1		
194 180										1		2	
179 165													
164 150												1	
149 135									1	2	4	1	1
134 120							1	1		2	3		
119 105								1	1	3	2		
104 90										1	2	1	
89 75										1	1		
74 60						1				1			
59 45		1	1										

$r = .44$

Table LXXXIII Scatter Diagram Showing the Correlation Between Detroit Test and Assembly

Detroit \ Assembly	17 12	23 18	29 24	35 30	41 36	47 42	53 48	59 54	65 60	71 66	77 72	83 78
224 210											1	
209 195								1				
194 180								1	1		1	
179 165												
164 150							1					
149 135						1		4	1	2		1
134 120				1			2		1	1	1	1
119 105					1		2	1	1	1		
104 90			1				1		1	1		
89 75			1				1					
74 60					1		1					
59 45		1	1									

r = .56

Table LXXXIV Scatter Diagram Showing the Correlation Between Minnesota Manipulation (Placing) and Minnesota Manipulation (Turning)

Minnesota Manipulation (Placing)	Minnesota Manipulation (Turning)														
		570 541	540 511	510 481	480 451	450 421	420 391	390 361	360 331	330 301	300 271	270 241	240 211	210 181
196 210													1	1
211 225												3	2	
226 240									1		1	8	1	
241 255										1	6	3	1	
256 270								1		1	4			
271 285									1					
286 300														
301 315														
316 330			1											
331 345														
346 360														
361 375														
376 390							1							
391 405		1												

r = .38

Table LXXXV Scatter Diagram Showing the Correlation Between Minnesota Manipulation (Placing) and Assembly

Minnesota Manipulation (Placing)	Assembly														
			17 12	23 18	29 24	35 30	41 36	47 42	53 48	59 54	65 60	71 66	77 72	83 78
196 210										1	1			
211 225									1	2		2		
226 240				1		1			1	3	1	2	2	
241 255							1	1	3		2	1	1	2
256 270				1					3	1	1			
271 285					1									
286 300														
301 315														
316 330				1										
331 345														
346 360														
361 375														
376 390						1								
391 405			1											

r = .56

Table LXXXVI Scatter Diagram Showing the Correlation Between Minnesota Manipulation (Turning) and Assembly

Minnesota Manipulation (Turning)	Assembly														
				17 12	23 18	29 24	35 30	41 36	47 42	53 48	59 54	65 60	71 66	77 72	83 78
181 210											1				
211 240										1		1	1	1	1
241 270					1				1	2	4	1	3	1	1
271 300					1			1		3	1	3	1	1	
301 330										1	1				
331 360						1	1								
361 390										1					
391 420							1								
421 450															
451 480															
481 510															
511 540					1										
541 570				1											

$r = .64$

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