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An experimental Investigation of the Relationship of Perceptual Speed to Motor Speed

Richard F. Wierman

Wierman — Relationship of Perceptual Speed to Motor Speed

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AN EXPERIMENTAL INVESTIGATION OF THE RELATIONSHIP OF PERCEPTUAL SPEED TO MOTOR SPEED

By

Richard F. Wierman

A Thesis
In partial fulfillment of the
Requirements for the Degree of
Master of Arts in Psychology

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This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of the University of New Mexico in partial fulfillment of the requirements for the degree of

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Introduction and Review of the Literature. Three major theories have been advanced by engineers and psychologists to explain the accident histories of individuals. The first is the Theory of Chance Distribution which states that accidents are due solely to chance and beyond the control of the individual. The second explanation offered is that of Biased Distribution. This theory claims that all persons are equally susceptible to accidents and that the occurrence of a single accident predisposes the individual to other accidents. This could be the result of such factors as worry, nervousness, etc. The Theory of Unequal Liability states that some individuals are inherently more susceptible to accidents than are others, and are therefore "accident prone."

The early investigations by Greenwood and Wood[1] during World War I and those of Newbold[2] in 1926 covering 16,000 cases support the explanations offered by the Theory of Unequal Liability. More recent studies by Wong and

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[1]M. Greenwood and H. M. Woods, "The Incidence of Industrial Accidents With Specific Reference to Multiple Accidents," Industrial Fatigue Research Board Report, 1919, No. 4.

[2]E. M. Newbold, "A Contribution to the Study of the Human Factors in the Causation of Accidents," Industrial Fatigue Research Board Report, 1926, No. 34.

Hobbs[3] and Rawson[4] support this conclusion.

It has been stated[5] that approximately 90 per cent of industrial accidents may be attributed to human errors or defects. That one cause of "accident proneness" may be purely psychological is not denied. In a study by Forester[6] roughly 14 per cent of the "accident prone" individuals showed evidence of being maladjusted in their work. Whitlock and Crannell's[7] studies of steelworkers and the reports of Tellmann and Hobbs[8] on automobile drivers who were judged "accident prone" support Forester's estimate of the incidence of personality factors in accident causation.

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[3]W. A. Wong and G. E. Hobbs, "Personal Factors in Industrial Accidents; A Study of Accident Proneness in an Industrial Group," Industrial Medicine, 1949, 18, p. 291-294.

[4]A. J. Rawson, "Accident Proneness," Psychosomatic Medicine, 1944, 6, p. 88-94.

[5]N. J. Stump, "How Inefficient Vision Causes Industrial Accidents," Optometrist Weekly, 1946, 37, p. 915.

[6]N. K. Forester, "Mental Abilities: Their Relation to Industrial Accidents," Industrial Medicine, 1937, 6:4, p. 293.

[7]J. B. Whitlock and C. W. Crannell, "An Analysis of Certain Factors in Serious Accidents in a Large Steel Plant," Journal of Applied Psychology, 1949, 5:33, p. 494-498.

[8]W. A. Tillmann and G. E. Hobbs, "The Accident Prone Automobile Driver; a Study of Psychiatric and Social Background," American Journal of Psychiatry, 1949, 106, p. 321-331.

These aforementioned studies indicate the validity of the concept of "accident proneness" and the incidence of accidents roughly being 80 per cent due to factors other than personality problems.

In the light of these investigations and as a result of his own research, Drake has hypothesized that "Accident proneness is a phenomenon associated with discrepancies in level between perceptual and motor reaction."[9] In a study of forty female operators from one metal working department of a factory, Drake[10] concluded that persons whose perceptual level is equal to or higher than their motor level are relatively safe, while those whose perceptual level is lower than their motor level are accident prone. Simply stated, the implication is that people who see faster than they reach are safe and those who reach more quickly than they see are prone to accidents.

Statement of the Problem. The main problems of this investigation were to discover:

1. What relationship, if any, exists between perceptual and motor speed and

2. Whether or not individuals who had scores on

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[9]Charles A. Drake, Personnel Selection by Standard Job Tests. New York: McGraw-Hill, 1942.

[10]Drake, op. cit.

visual tests which were above the mean and who had scores on motor tests below the mean present a history of fewer accidents when compared with persons whose scores on visual tests were below the mean and who were above the mean in motor test scores.

Importance of the Study. The importance of validating this perceptual-motor hypothesis is evident in its many practical applications. Farmer and Chambers'[11] investigations, based upon the conclusions of Greenwood and Wood[12] for the British Industrial Fatigue Research Board, offered the possibility of accident reduction within industry through the identification of individuals having "accident proneness" characteristics. If these persons can be identified, a substantial reduction in accidents may result. This could be accomplished by not hiring those individuals or more importantly by not assigning them to jobs which offer the greatest opportunity for accidents. However, this would not mean that industry should relax its efforts to provide physical safeguards.

Only with a combination of selection and identifying procedures and a provision of physical safeguards can

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[11]Farmer and Chambers, "A Study of Personal Qualities in Accident Proneness and Proficiency," Industrial Fatigue Research Board Report, 1929, No. 55.

[12]Greenwood and Wood, op. cit.

accidents in industry be reduced.

Procedure. The subjects for the study were sixty university students enrolled in a second semester course of General Psychology. They were not informed as to the purpose of the experiment until all had completed the tests. The tests were administered in two sessions. The first four were given during the first session and tests five to eight were given one week later. All of the tests were of a work-limit variety wherein a specified number of pieces were manipulated and scores were recorded as the time taken to complete the task. Two of the tests were inspection or visual perception tests and the remaining six were motor manipulation tests.

Drake[13] in his study used two tests of perceptual speed and two of motor manipulation. His visual tests included the Spiral Inspection Test which was made up of 100 small aluminum spirals. Fifty of these were punched with a small hole two and one half turns from the end and were considered as "standard." The remaining 50 were punched at various distances other than the standard. The subject separated the standard from the others. The second test was composed of 120 colored metal pencil cases, which the

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[13]Drake, op. cit.

accidents in industry are reduced.

Procedure. The subjects for the study were sixty university students enrolled in a second semester course of General Psychology. They were not informed as to the purpose of the experiment until it had completed the tests. The tests were administered in two sessions. The first four were given during the first session and tests five to eight were given one week later. All of the tests were of a work-limit variety wherein a specified number of pieces were manipulated and scores were recorded as the time taken to complete the task. Two of the tests were manipulation of visual perception tests and the remaining six were motor manipulation tests.

Tests. In this study used two tests of perception, speed and two of motor coordination. His visual tests included the Motoral Inspection Test which was made up of 100 small aluminum spirals. Fifty of these were punched with a small hole too and one half turns from the end and were considered as "standard." The remaining 50 were punched at various distances other than the standard. The subject separated the standard from the others. The second test was composed of 120 colored metal pencil ends, which the

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Symonds, op. cit.

subject separated according to color into six compartments. Of these, thirty were punched, and were sorted in a separate box.

The motor tests used by Drake were a turning test and a pin board test. For the first the subjects turned ten pair of machine screws into threaded holes in a vertical steel plate. The second task involved the simultaneous placing of pins into parallel rows of holes in a tray.

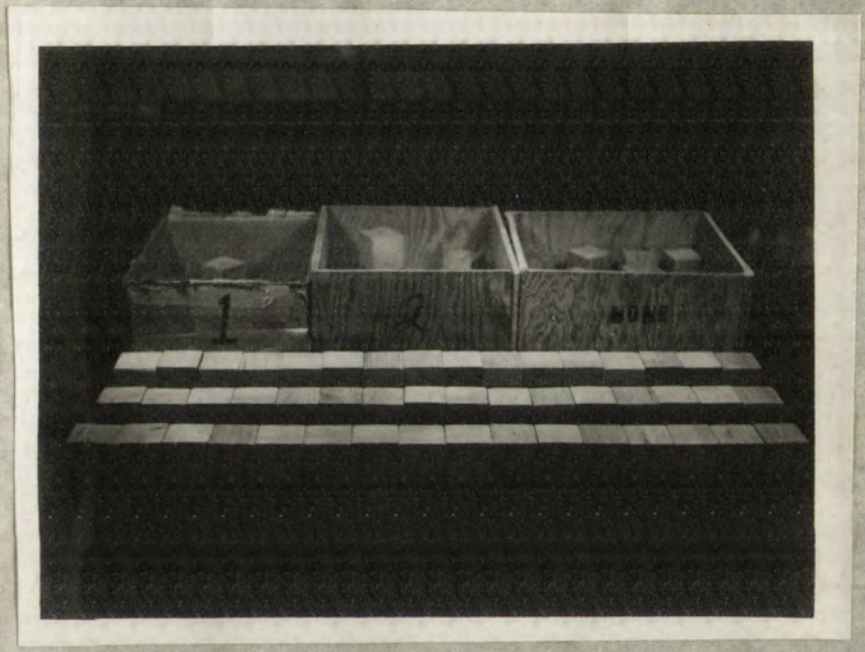
In this investigation no effort was made to duplicate exactly the apparatus used by Drake, but the test battery did include turning and sorting tests. The following tests were used:

Test I. Block Sorting Test
Test II. Block Packing Test
Test III. Knob Unscrewing Test
Test IV. Knob Screwing Test
Test V. Tube Sorting Test
Test VI. Knob Unscrewing Test
Test VII. Know Screwing Test
Test VIII. Block Packing Test

Test I, Plate I consisted of sixty two inch square wooden blocks. Ten of these had a small black spot located on one of the sides. Twenty of the blocks had two defects, e.g., black dots, located on adjoining or opposite sides of

the square. The remaining thirty had no defects. The subjects separated these blocks according to the number of defects on the block.

Plate I Block Sorting Test



In Test II, Plate II, the same blocks used in Test I were packed into a box in the shortest possible time.

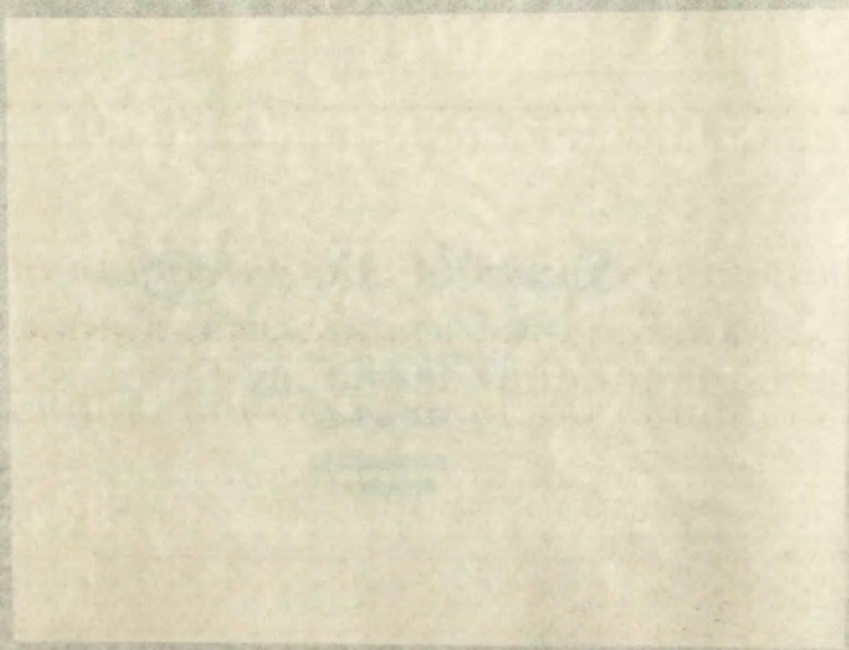
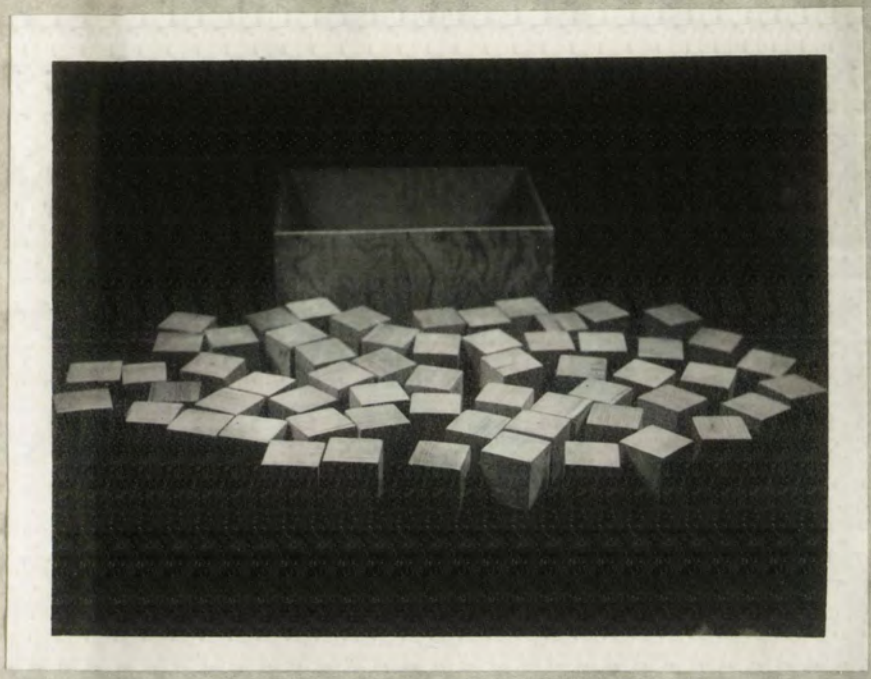


Plate II Block Packing Test



As a turning test, Test II, Plate III, required the subject to unscrew twenty knobs, measuring 1 11/16 inches in diameter, from a board on which they had been secured.

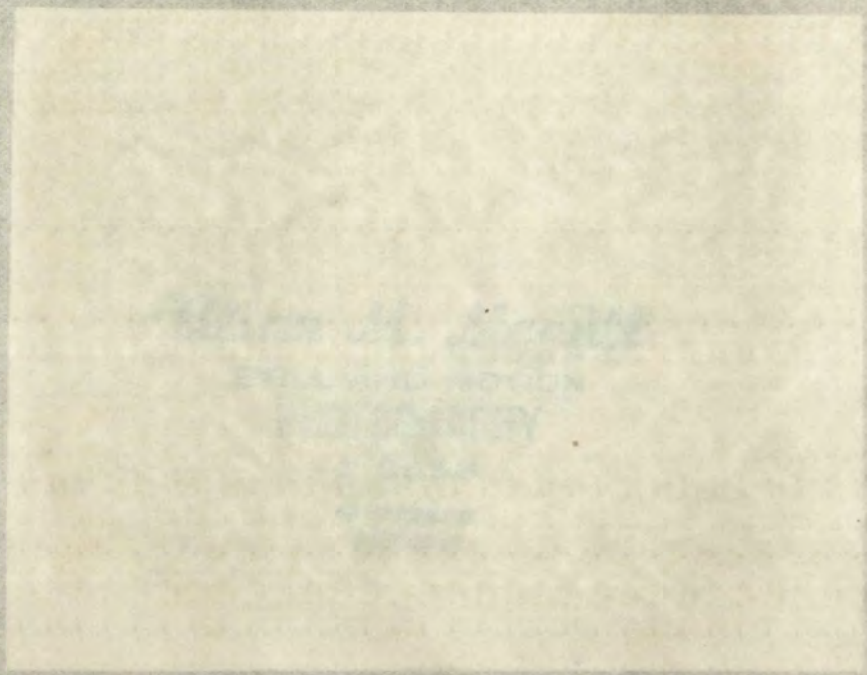
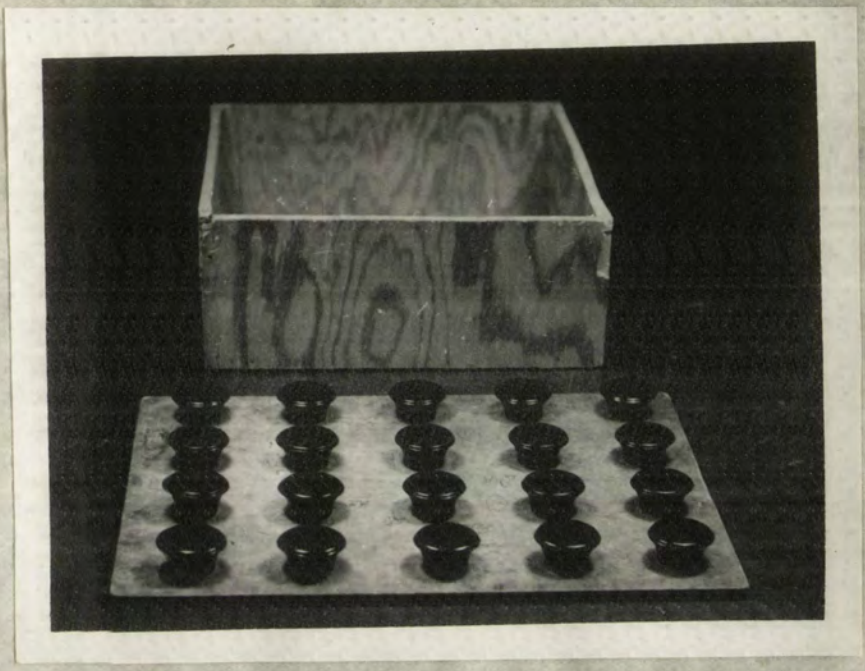


Plate III Knob Unscrewing Test



Test IV, Plate IV used the same knobs. The operation demanded that the subject screw these knobs onto the board in the quickest possible time.

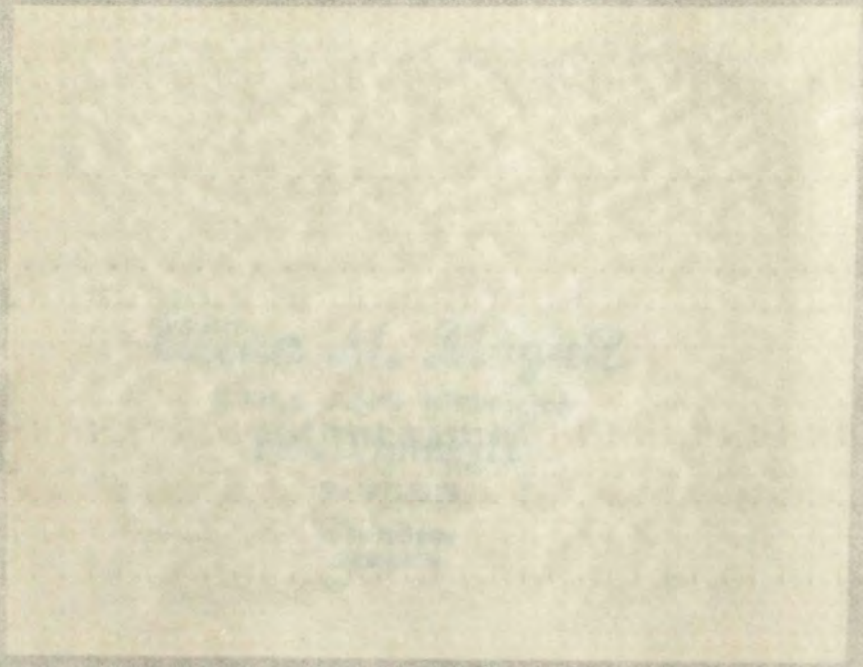
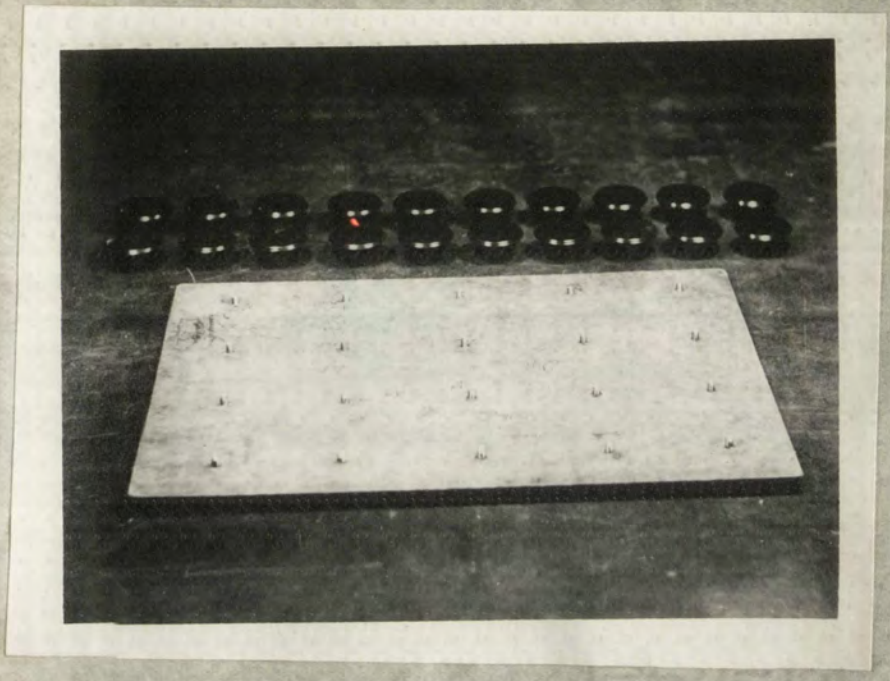


Plate IV Knob Unscrewing Test



The second session of Testing began with Test V, Plate V, a test of visual perception. One hundred and twelve hollow aluminum tubes, four inches in length were separated into two groups. Twenty of the tubes had a hole drilling 1/2 inch from the end into one surface of the tube. The remaining tubes exhibited no defects.

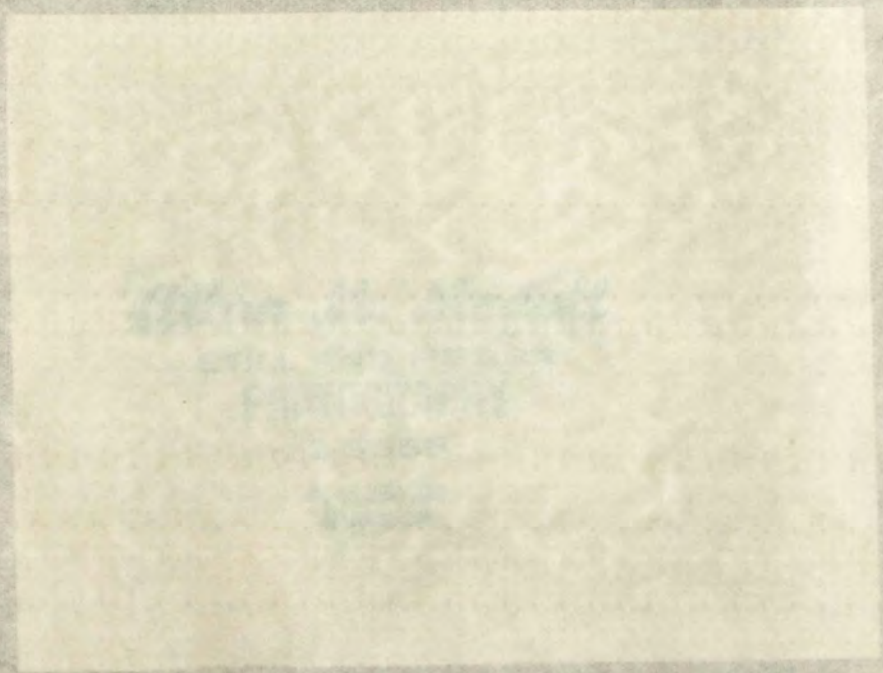


Plate V Tube Sorting Test

Test VI, Plate VI, followed the same procedure as Test III, with the exception of the size of the knobs used. The twenty knobs which were unscrewed were 2 1/4 inches in diameter.

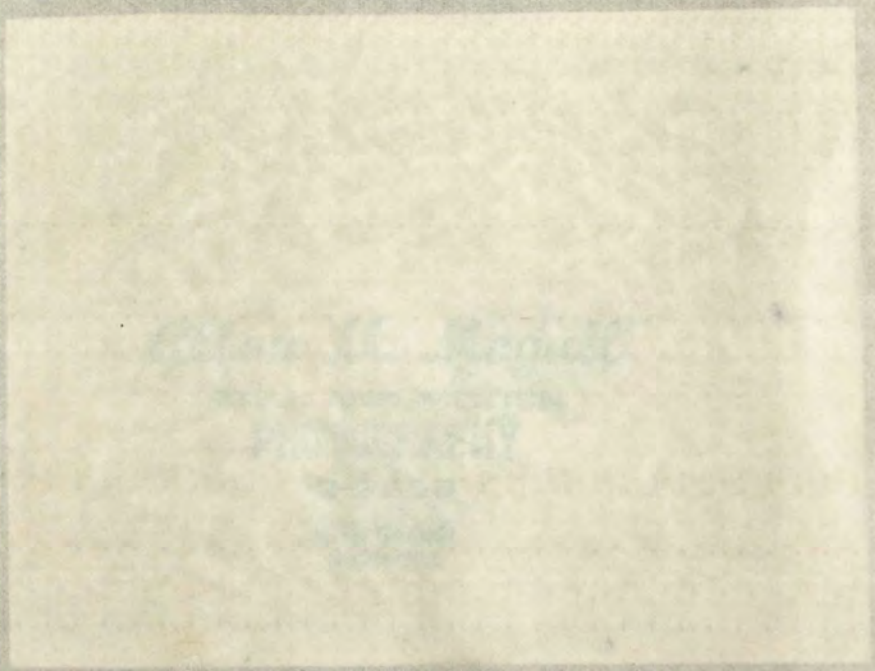
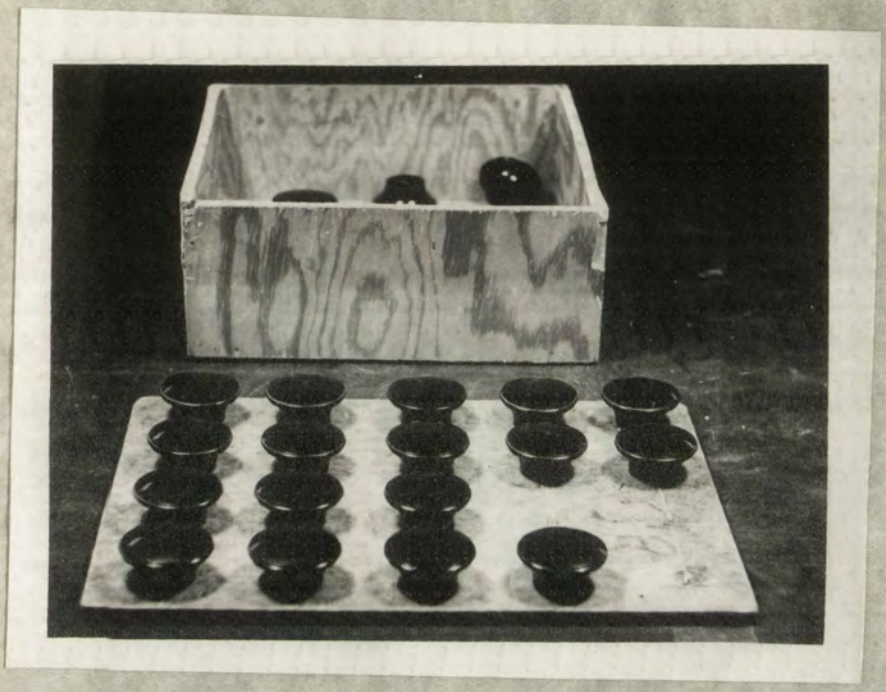


Plate VI Knob Unscrewing Test



Securing these knobs to the board comprised the operation of Test VII, Plate VII.

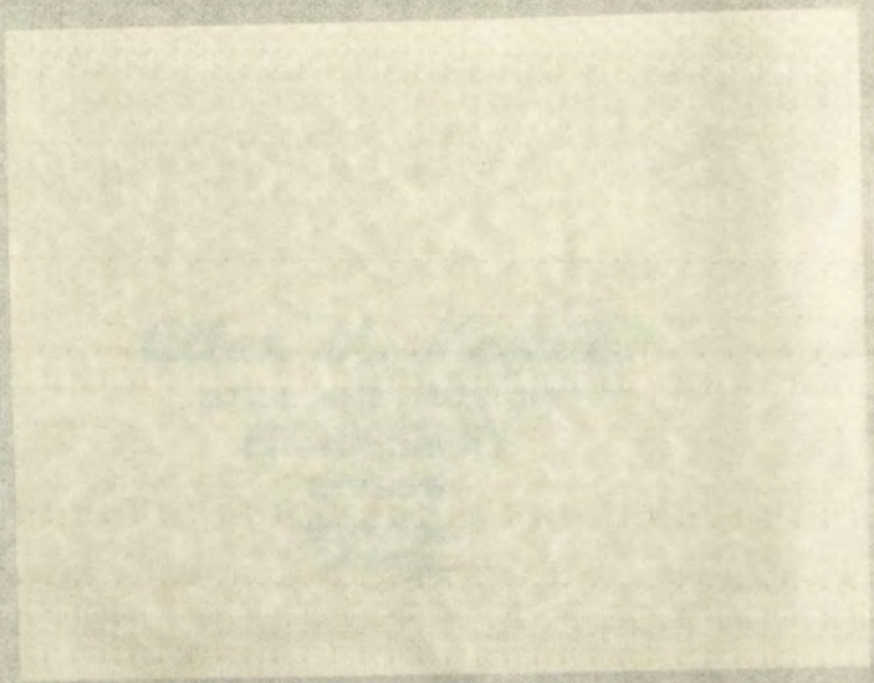
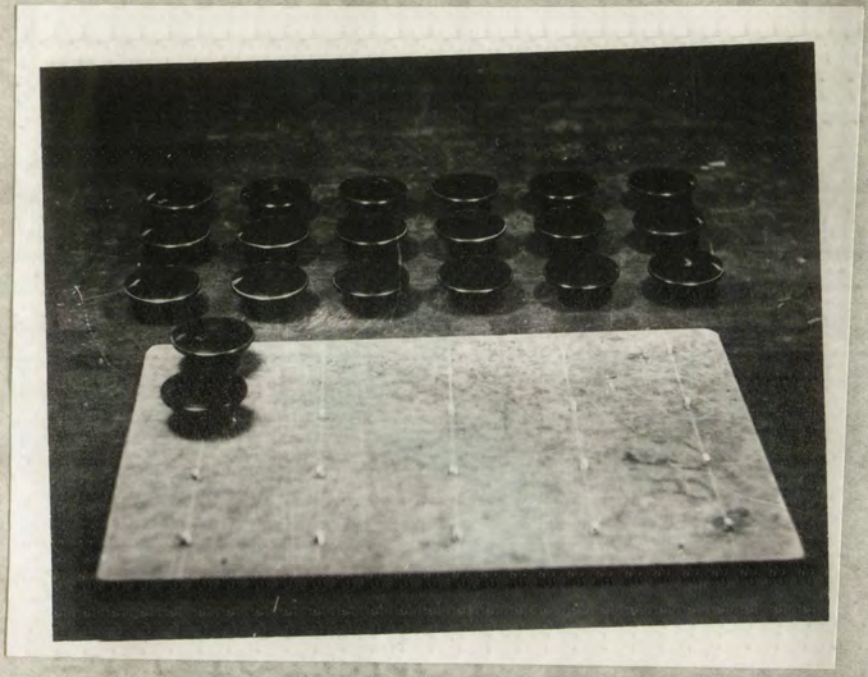


Plate VII Knob Screwing Test



The final motor manipulation test given, Test VIII, Plate VIII, was comprised of sixty-four one inch square blocks. These were to be packed into a wooden tray as quickly as possible.

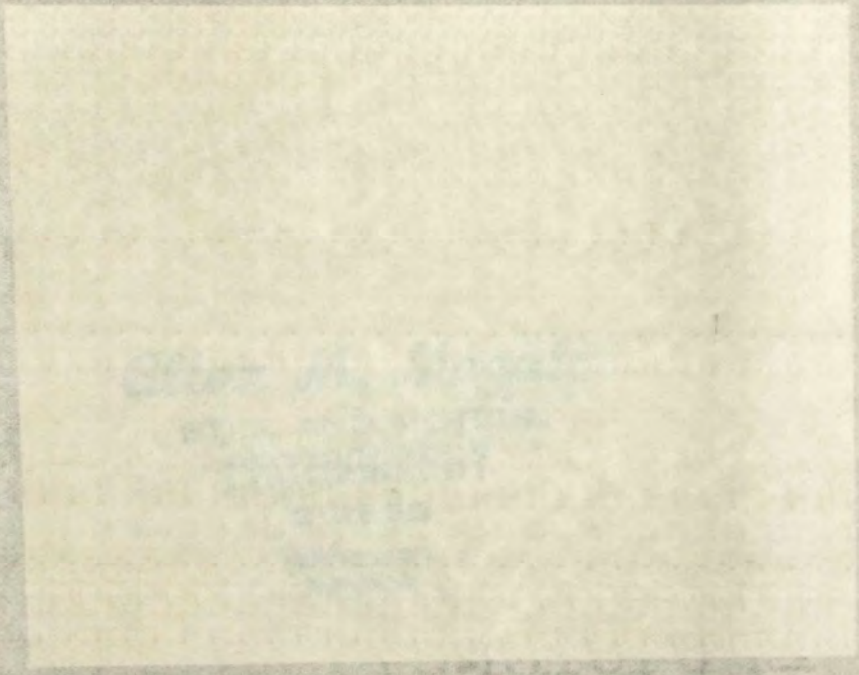
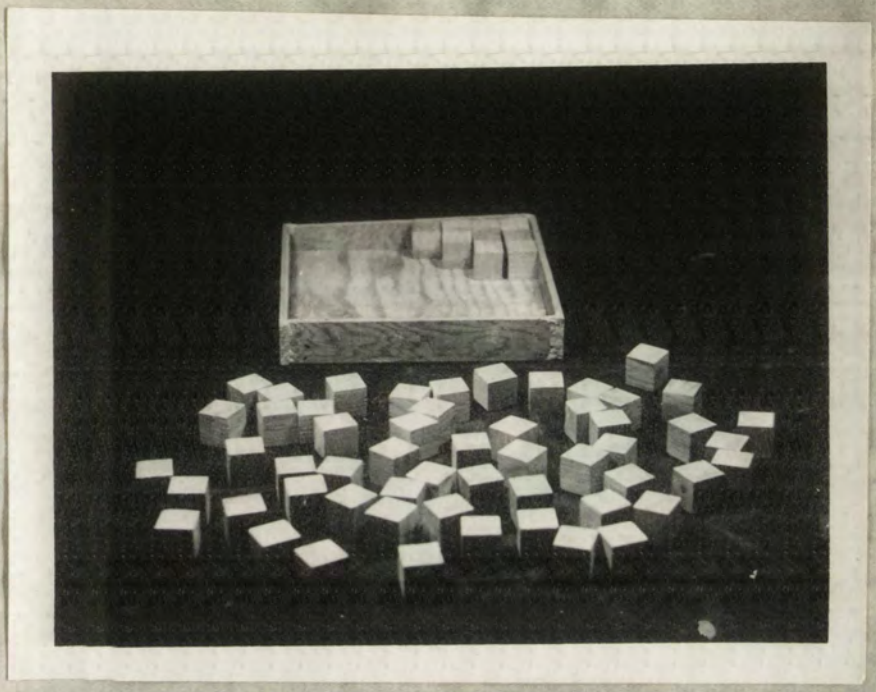
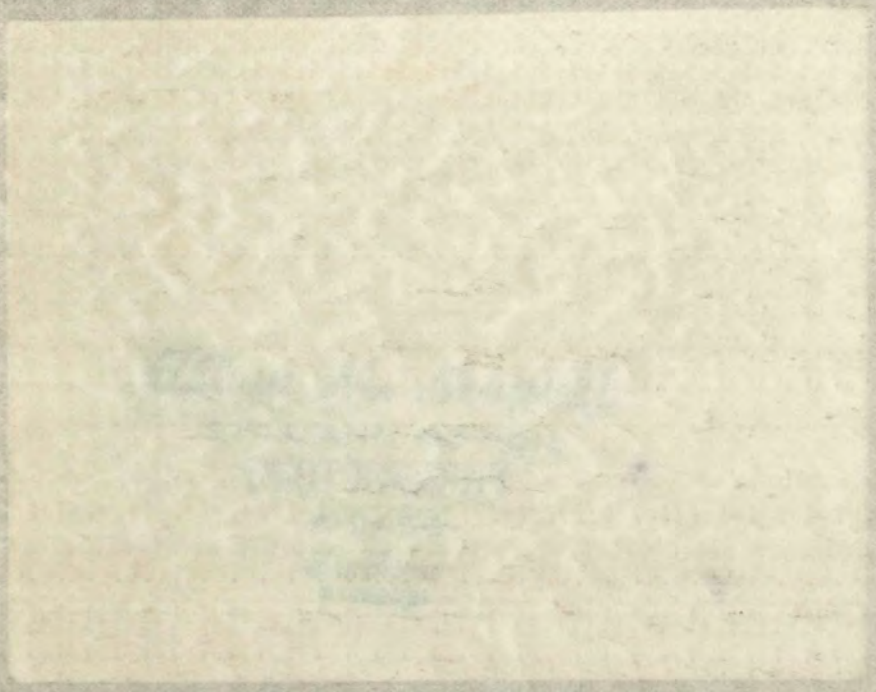


Plate VIII Block Packing Test



It is recognized that none of these tests is purely visual or purely motor. Each has some feature of visual and motor performance. In designing these tests an effort was made to hold this at a minimum. The sorting tests, classified as visual tests chiefly required a ballistic type of movement. The subject picked up the test material and after inspecting it, threw it into the assigned box. Visual requirements for Packing Test II were at a minimum. The only visual demand was that the subject could see the blocks and the box into which they were packed. This test



used gross movements. The Screwing and Unscrewing Tests, also classified as motor, necessitated the use of finer wrist and finger movements. Here also, vision played a minor role. When the knob was carried to the board, it was impossible for the subject to align the screw and the thread by looking at them. Because of this restriction, a major part of the visual element in Drake's Turning Test was eliminated in this operation.

The subject stood before a table on which the test materials were placed in the order indicated. The experimenter stood to the side and rear of the subject and read to the subject the instructions given with each test.[14] For each test a record was made of the time to complete the task as measured by a stop watch. On the completion of each task, the subject left the table and was seated away from it. The experimenter then removed the completed test materials and placed the succeeding test on the table.

Each of the eight tests was administered to sixteen individuals, whose records were not included in this study, in order to standardize test instructions and arrangement of test materials. For Sorting Tests I and V, the compartments into which the materials were to be placed were

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[14]See Appendix, pages 35 to 40 , for oral instructions given with each test.

located on the center of the table. The blocks to be sorted in Test I were aligned in three rows of twenty blocks each, between the subject and the boxes into which they were to be placed. The tubes of Test V were emptied onto the table into a pile directly in front of the subject.

In Packing Tests II and VIII the blocks were separated on the table, lying between the subject and the box into which they were to be packed.

The board on which the knobs were secured in the Unscrewing Tests III and VI was placed directly in front of the subject. To its immdeiate front on the table was the box into which the unscrewed knobs were to be thrown.

In Screwing Tests IV and VII the board on which the knobs were to be secured was placed on the table between the subject and the rows of knobs. The knobs were turned thread down.

Various problems were confronted in standardizing the instructions for the tests. "Do you have any questions?" was included in each of the tests because many of the original sixteen subjects asked if there was any specified order in manipulating the materials. To this question a negative reply was given. The phrases "Pick up one knob at a time. Screw it all the way onto the board. Repeat this operation until all knobs are fastened to the board," were included for the following

located on the center of the table. The blocks to be
sorted in Test I were aligned in three rows of twenty
blocks each, between the subject and the boxes into which
they were to be placed. The tubes of Test I were emptied
onto the table into a pile directly in front of the subject.

In Testing Tests II and VIII the blocks were separated on the table, lying between the subject and the box into which they were to be packed.

The board on which the knobs were secured in the Unscrewing Tests III and VI was placed directly in front of the subject. To its immediate right was placed the box into which the unscrewed knobs were to be placed.

In Screwing Tests IV and VII the board on which the knobs were to be secured was placed on the table between the subject and the pole of knobs. The knobs were thread down.

Various problems were confronted in standardizing the instructions for the tests. "Do you have any questions?" was included in each of the tests because many of the original sixteen subjects asked if there was any specified order in manipulating the materials. To this question a negative reply was given. The pieces were up one knob at a time. Screw it all the way into the board. Repeat this operation until all knobs are fastened to the board." were included for the following

reason. A few of the original sixteen subjects secured the knobs, so that the screws were engaged with the first few threads of the knobs. Then, with a rapid movement, using the palm of the hand, all of the knobs in a row were turned onto the board in one operation. Standardization of the procedure was accomplished by including the above quoted statement.

The experimental design used for this study did not necessitate the use of experimental and control groups, since the purpose of the investigation was to determine the relationship of visual to motor speed for a typical college group.

After the subjects were tested and before the scores between the various tests were correlated, the experimentor interviewed each subject individually to obtain the subject's accident history.[15] In following such a procedure the objectivity of the interview was increased. The interviewer had no knowledge of how the subjects' test scores would correlate with his accident history.

Three measures of accidents were used. These three,

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[15]See Appendix, page 41 , for form used for accident history and actual results obtained for one subject.

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[5]See Appendix, page 4, for form used for accident history and actual results obtained for one subject.

which are all classified as major accidents, were: (a) broken bones; (b) scars; and (c) automobile accidents. It was felt that data on minor accidents should not be used in this investigation for two reasons. In a survey of the literature, the majority of the studies indicate a small relation between major and minor accidents. Secondly, the general belief among psychoanalysts is that minor accidents may often be due to psychological mechanisms in personality factors.[16] Arbitrarily the following provisions were set up for each of these three groups. The frequency for scars and fractures was not based upon the number of scars or broken bones, but rather the number of times the accident occurred. For example, if the subject had fallen from a roof and had fractured three ribs and the left femur, it was recorded as a frequency of one. If, however, the individual fell again at a later time and broke the same bones it was recorded as two. If scars or fractures were the result of automobile accidents they were not included. Only scars that were acquired within the last five years were recorded. No operational scars were included.

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[16] A. Mintz and M. L. Blum, "A Re-examination of the Accident Proneness Concept," Journal of Applied Psychology, 1949, 33, 3, p. 195-211.

In tabulating the frequency of automobile accidents, three types were considered. These were: (a) accidents where the subject "ran into" another car; (b) those wherein a second car hit the subject's car; and (c) those wherein the subject's car "rolled over" or "smashed" into some stationary object such as a tree, culvert, etc. It was required that the subject be driving the car and that the car be in motion at the time of the accident.

Results. The time required to complete each test, measured to the tenth of a second, was taken as the score of perceptual or motor speed. The scores were then plotted on a scatter diagram.[17] By inspection the effects of curvilinearity or unusual scores could be observed. The computational method developed by Kelly and McNemar was used to obtain the correlations. The resulting coefficients are recorded in Table I.

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[17]See Appendix, pages 42 to 70 , for scatter diagram plate.

TABLE I

INTER-TEST CORRELATION COEFFICIENTS

	Test I	Test II	Test III	Test IV	Test V	Test VI	Test VII
Test I							
Test II	-.1188						
Test III	-.1314	+.0955					
Test IV	-.1058	+.1560	+.5371				
Test V	+.4622	-.0225	-.0211	-.1022			
Test VI	+.0133	+.2893	+.6541	+.3479	+.0820		
Test VII	+.1789	+.1349	+.1411	+.4790	+.0355	+.2583	
Test VIII	+.4299	+.5071	+.0166	+.1241	+.2219	+.1590	+.2231

Examination of Table I shows small correlations between Visual Tests I and V with Motor Tests II, II, IV, VI, and VII. Correlations between Packing Test II and Screwing Tests II, IV, VI, and VII ranged from +.0955 to +.2893. The intercorrelations for Screwing Tests II, IV, VI, and VII ranged from +.1411 to +.6541.

The standard deviation to measure the reliability of the r for this single sample was then computed. The formula used for the standard error of r was $\sigma_{12} = \frac{1-r_{12}^2}{\sqrt{N}}$. The resulting

TABLE I

INTER-TEST CORRELATION COEFFICIENTS

	Test I	Test II	Test III	Test IV	Test V	Test VI	Test VII
Test I							
Test II	-.1168						
Test III	-.1314	+.0955					
Test IV	-.1058	+.1560	+.5371				
Test V	+.1622	-.0225	-.0211	-.1022			
Test VI	+.0133	+.2893	+.6941	+.3479	+.0820		
Test VII	+.1789	+.1349	+.1411	+.1790	+.0355	+.2893	
Test VIII	+.2299	+.3071	+.0166	+.1241	+.2219	+.1590	+.2231

Examination of Table I shows small correlations between Visual Tests I and V with Motor Tests II, III, IV, VI, and VII. Correlations between Peeling Test II and Screwing Tests III, IV, VI, and VII ranged from +.0955 to +.2893. The intercorrelations for Screwing Tests III, IV, VI, and VII ranged from +.1411 to +.6941.

The standard deviation to measure the reliability of the r for this single sample was then computed. The formula used for the standard error of r was $\sigma_r = \frac{1-r^2}{\sqrt{N}}$. The resulting

measures of standard error are recorded in Table II along with the correlations to which they relate.

TABLE II

STANDARD ERROR OF TEST INTER-CORRELATIONS

(Figures in parentheses indicate r.)

	Test I	Test II	Test III	Test IV	Test V	Test VI	Test VII
Test I							
Test II	(-.1188) .1273						
Test III	(-.1314) .1269	(+.0955) .1279					
Test IV	(-.1058) .1277	(+.1560) .0977	(+.5371) .0919				
Test V	(+.4622) .1015	(-.0225) .1284	(-.0211) .1290	(-.1022) .1278			
Test VI	(+.0133) .1291	(+.2893) .1183	(+.6541) .0739	(+.3479) .1135	(+.0820) .1282		
Test VII	(+.1789) .1250	(+.1349) .1267	(+.1411) .1265	(+.4790) .0995	(+.0355) .1289	(+.2483) .1205	
Test VIII	(+.4299) .1052	(+.5071) .0959	(+.0166) .1291	(+.1241) .1271	(+.2219) .1227	(+.1590) .1258	(+.2231) .1227

For example, the inter-correlation of Test III with Test VII is +.6541 with a standard error of .0739.

The mean time score for the sixty subjects was computed for each test. These results are recorded in Table III.

TABLE III

MEAN SCORE ON TESTS

(Given in minutes, seconds, and hundredths of seconds)

Test I	Test II	Test III	Test IV
2' 49.20"	0' 56.86"	0' 51.79"	1' 28.33"
Test V	**Test VI**	**Test VII**	**Test VIII**
4' 01.31"	0' 41.64"	1' 24.16"	1' 00.61"

The inter-test scores on visual and motor tests as represented on the scatter diagrams in the appendix were divided into quadrants. The mean was used as the dividing point.

As previously stated, Drakes' hypothesis indicates that people who reach more quickly than they perceive are "accident prone." The accident histories of those subjects whose perceptual speed was above the mean and who had

motor test scores below the mean were tabulated against those subjects who scored below the mean in visual tests and above the mean in motor tests. These results are given in Table IV.

The column headings in Table IV indicate which test results are cited, how many persons made scores falling into the fast visual-slow motor versus the fast motor-slow visual pattern, and lastly the number of accidents reported for those individuals in each of the groups. The anticipated outcome, according to Drake's hypothesis, is that although the number of persons in each group should be approximately equal, the number of accidents should be greater in the fast motor-slow vision group.

motor test scores below the mean were tabulated against those subjects who scored below the mean in visual tests and above the mean in motor tests. These results are given in Table IV.

The column headings in Table IV indicate which test results are cited, how many persons made scores falling into the fast visual-slow motor versus the fast motor-slow visual pattern, and lastly the number of accidents reported for those individuals in each of the groups. The anticipated outcome, according to Drake's hypothesis, is that although the number of persons in each group should be approximately equal, the number of accidents should be greater in the fast motor-slow vision group.

TABLE IV

ACCIDENT FREQUENCY OF SUBJECTS ABOVE THE MEAN IN VISUAL TIME SCORE AND BELOW THE MEAN IN MOTOR TIME SCORE AS COMPARED WITH SUBJECTS BELOW THE MEAN IN VISUAL TIME SCORE AND ABOVE THE MEAN IN MOTOR TIME SCORES WHEN VISUAL TESTS I AND V WERE COMPARED WITH MOTOR TESTS II, III, IV, VI, AND VII

Tests	Vision (Slow)		Motor (Fast)	Vision (Fast)		Motor (Slow)
	Accident Type	No. of Persons	Accident Frequency	Accident Type	No. of Persons	Accident Frequency
I&III	Broken bones	12	12	Broken bones	13	2
	Automobile accidents	12	10	Automobile accidents	13	2
	Scars	12	12	Scars	13	6
I&IV	Broken bones	14	13	Broken bones	16	5
	Automobile accidents	13	17	Automobile accidents	14	6
	Scars	14	15	Scars	16	10
I&VI	Broken bones	10	7	Broken bones	14	2
	Automobile accidents	10	12	Automobile accidents	12	2
	Scars	10	12	Scars	14	6
I&VII	Broken bones	8	17	Broken bones	10	3
	Automobile accidents	8	13	Automobile accidents	10	3
	Scars	8	6	Scars	10	4
V&II	Broken bones	14	10	Broken bones	10	2
	Automobile accidents	14	17	Automobile accidents	9	10
	Scars	14	13	Scars	10	4
V&III	Broken bones	12	14	Broken bones	12	3
	Automobile accidents	12	14	Automobile accidents	11	5
	Scars	12	13	Scars	12	2
V&VI	Broken bones	14	10	Broken bones	12	4
	Automobile accidents	14	14	Automobile accidents	9	2
	Scars	14	9	Scars	12	3
V&VII	Broken bones	12	11	Broken bones	16	7
	Automobile accidents	12	15	Automobile accidents	13	7
	Scars	12	13	Scars	16	5

Tests	Vision (Blow) Accident Type	No. of Persons	Motor (Fast) Accident Frequency	Vision (Fast) · Motor (Slow) Accident Type	No. of Persons	Accident Frequency
IAIII	Broken bones	12	12	Broken bones	13	2
	Automobile accidents	12	10	Automobile accidents	13	2
	Scars	12	12	Scars	13	6
IAIV	Broken bones	14	13	Broken bones	16	3
	Automobile accidents	13	12	Automobile accidents	15	5
	Scars	14	13	Scars	15	10
IAVI	Broken bones	10	7	Broken bones	14	2
	Automobile accidents	20	12	Automobile accidents	12	2
	Scars	20	14	Scars	14	6
IAVII	Broken bones	8	12	Broken bones	10	3
	Automobile accidents	8	13	Automobile accidents	10	3
	Scars	8	6	Scars	10	6
VAII	Broken bones	14	10	Broken bones	10	3
	Automobile accidents	14	12	Automobile accidents	9	4
	Scars	14	13	Scars	10	4
VAIII	Broken bones	12	14	Broken bones	12	3
	Automobile accidents	12	14	Automobile accidents	11	3
	Scars	12	13	Scars	13	5
VAVI	Broken bones	14	10	Broken bones	12	4
	Automobile accidents	14	14	Automobile accidents	9	2
	Scars	14	9	Scars	12	3
VAVII	Broken bones	12	12	Broken bones	10	2
	Automobile accidents	12	13	Automobile accidents	13	3
	Scars	12	13	Scars	13	4

From an inspection of Table IV it is noted that in some of the cases the number of persons included under automobile accidents is smaller than the number included within the same test comparisons. In those cases not all of the subjects were automobile drivers. Only those tests were included in the comparison in Table IV which exhibited a low correlation.

In all of the comparisons made in Table IV, the groups which were above the mean on the motor tasks and below the mean on the visual tests presented a history of greater accident frequency for all three types of accidents considered.

Discussion. As shown in Table I, the correlation between Visual Tests I and V and Motor Tests II, II, IV, VI and VII were no greater than $\pm$.1315. Correlation between Test I and Test III was -.1314. The minimum value of r required for significance at the five per cent level of confidence for this size sample is .253. None of the correlations approached this value. In comparing Table I with Table III it could not be shown that a true r other than zero exists for the population from which this sample was drawn. Test I and II had an r of -.1188 with a standard error of .1273; r between I and IV equals -.1058, $\sigma_{r_{12}}$ = .1277, I & VI, r= +.0133, $\sigma_{r_{12}}$ of .1291. In a comparison between the second visual test used, Test V, with the motor tests, a comparable

From an inspection of Table IV it is noted that in some of the cases the number of persons included under automobile accidents is smaller than the number included within the same test comparisons. In these cases not all of the subjects were automobile drivers. Only those tests were included in the comparison in Table IV which exhibited a correlation.

In all of the comparisons made in Table IV, the groups which were above the mean on the motor tests and below the mean on the visual tests presented a history of greater accident frequency for all these types of accidents combined.

Discussion. As shown in Table I, the correlation between Visual Tests I and V and Motor Tests II, III, IV, VI and VII were no greater than $\frac{1}{2}$ .1145. Correlation between Test I and Test III was -.1114. The minimum value of r required for significance at the five per cent level of confidence for this size sample is .273. None of the correlations approached this value. In comparing Table I with Table III it could not be shown that a true r other than zero exists for the population from which this sample was drawn. Test I and II had an r of -.1188 with a standard error of .1273; between I and IV equals -.1098 ± .1277; I & VI = +.0133; of .1291. In a comparison between the optical visual test used, Test V, with the motor Tests I compared

result occurred. The correlation of Test V with Test II was -.0225 and a standard error of .1284. The other correlations and standard errors for Test V were: Test V and III, r=.0211, $\sigma_{r_{12}}$ = .1290; Test V and Test IV, r = -.1022, $\sigma_{r_{12}}$ = .1278; Test V and Test VI, r = +.0820, $\sigma_{r_{12}}$ = .1282; and between Test V and Test VII, r = +.0355 with a standard error of .1289. On applying the standard error to the obtained correlation of the above mentioned tests, all included within their range a correlation of zero. It was impossible to account for these correlations as being the result of anything but chance fluctuations in random sampling.

On comparing tests having similar operations on different materials as shown in Tables I and II, the following relationships were established. These are given in Table V.

TABLE V

CORRELATION AND STANDARD ERRORS FOR TESTS USING SIMILAR OPERATIONS AND DIFFERENT MATERIALS

Tests	Correlation	Standard Error
I & V	+.4622	.1015
II & VIII	+.5071	.0959
III & VI	+.6541	.0739
IV & VII	+.4790	.0995

An inspection of Table V shows all correlations to be above +.46. Each of these is significant at the one per cent level.

Table VI shows the results given when Tests using different operations and the same material were used.

TABLE VI

CORRELATIONS AND STANDARD ERRORS FOR TESTS HAVING DIFFERENT OPERATIONS AND SIMILAR MATERIALS

Tests	Correlation	Standard Error
III & IV	+.5371	.0919
VI & VII	+.2583	.1205

The correlation between Tests III and IV is significant at the one per cent level. The correlation between Tests VI and VII is not significant at the five per cent level of confidence.

These results indicate that the visual requirements as measured by Tests I and V were not testing the same factors which were required in the motor tests. Motor Packing tests when compared with motor turning tests were not correlated significantly from zero at the five per cent level of

An inspection of Table V shows all correlations to be above +.96. Each of these is significant at the one per cent level.

Table VI shows the results given when Tests using different operations and the same material were used.

TABLE VI

CORRELATIONS AND STANDARD ERRORS FOR TESTS HAVING DIFFERENT OPERATIONS AND SIMILAR MATERIALS

Tests	Correlation	Standard Error
III & IV	+.7371	.0479
VI & VII	+.2589	.1509

The correlation between Tests III and IV is significant at the one per cent level. The correlation between Tests VI and VII is not significant at the five per cent level of confidence.

These results indicate that the visual requirements as measured by Tests I and V were not testing the same factors which were required in the motor tests. Motor Packing tests when compared with motor turning tests were not correlated significantly from zero at the five per cent level of

confidence.

An inspection of the scatter diagrams for Test II indicated the presence of two divergent scores. In each case their effect was slightly to reduce the correlation value obtained. However, this effect at no time changed the significance of the correlations as previously reported. There was one divergent score in Test VII. The correlation between Tests VI and VIII was slightly raised due to the effects of this score. The significance of the correlation was changed. The one divergent score of Test VI had little effect on the r's obtained. It closely approximated the mean of the test distribution to which it was compared. The correlations obtained of Test VI with Tests III and IV were increased due to this divergent score, but again not significantly so. By inspection no effects of curvilinearity were found.

No effort was made in this investigation to correlate accident history with test scores. Table IV shows a comparison of accident records between those subjects whose perceptual speed was above the mean and whose motor speed was below the mean and those individuals whose perceptual motor test score ratio was reversed. As previously stated, in all cases those individuals who reacted more quickly than they perceived had a greater number of all types of accidents investigated. These results ten to substantiate Drake's hypothesis.

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Because of the agreement of this study and the work of Drake,[18] further investigation of the hypothesis is justified. Future studies are needed using larger samples. A continuous effort must also be made further to purify the tests. Such a battery should include Perceptual Visual Tests and both Packing and Turning Motor Tests. A comparison of the test scores with the correlation of the accidents within two equal successive time intervals, as advocated by Maritz,[19] should then be made. Such an investigation would greatly add to the information relating to the concept of "accident proneness."

Summary and Conclusions. A series of eight tests were developed and standardized for this investigation. They consisted of two visual inspection tests, two block packing tests and four turning tests. Each of the tests was of the work limit type, which required the subjects to sort, turn or pack items as quickly as possible. In designing the tests an effort was made to hold the motor requirements for the inspection and sorting tests at a minimum. Likewise, the visual requirements for the motor packing and turning tests was reduced. In this manner, it was possible

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[18] Drake, op. cit.

[19] J. S. Maritz, "On the Validity of Inference Drawn from the Tilting of Poisson and Negative Binomial Distributions to Observed Accident Data," Psychological Bulletin, 1950, 43, 5, p. 434-443.

[18]Drake, op. cit.

[19]J. S. Marks, "On the Validity of Inference Drawn from the Fitting of Poisson and Negative Binomial Distributions to Observed Accident Data," Psychological Bulletin, 1950, 47, 5, p. 413-441.

to compare an individual's motor speed to visual speed and investigate Drake's hypothesis that accidents are associated with discrepancies in the level between perceptual and motor reaction.

Sixty students were administered these eight tests to ascertain the relationship which existed between motor speed and visual speed for an average college group. The accident history for each subject was taken, using scars, fractures, and automobile accidents as the criteria. The accident histories of those individuals who scored above the mean on the perceptual tests and whose scores were below the mean on the motor tests were compared with those of subjects whose sorting perceptual test scores were below the mean and whose motor test scores were above the mean. The following conclusions were a result of those comparisons.

1. The correlation between perceptual and motor tests did not differ significantly from zero. As measured by these tests visual speed and motor speed are not related.

2. The correlation between turning motor tests and packing motor tests was not significant at the five per cent level of confidence.

3. In comparing the accident histories of the above mentioned groups, the results agreed with Drake's hypothesis. Those individuals who reacted more quickly than they perceived had a greater incidence of accidents in their

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1. The correlation between perceptual and motor tests did not differ significantly from zero. As measured by these tests visual speed and motor speed are not related.

2. The correlation between scoring motor tests and pecking motor tests was not significant at the five per cent level of confidence.

3. In comparing the accident histories of the above mentioned groups, the results agreed with Drake's hypothesis. These individuals who reacted more quickly than they perceived had a greater incidence of accidents in their

histories.

The results of this investigation would indicate that there is some relationship between "accident proneness" and the differences in the level of motor and perceptual reaction. Further investigation of this relationship would be advisable. The accident histories of individuals for two successive periods should be used as the criteria. This study indicated that both turning and packing tests should be used to measure motor speed, and each compared with the visual speed scores on inspection tests.

A review of the literature indicated that little work has been done in investigating this relationship. If it can be established that one of the factors in "accident proneness" is this discrepancy in perceptual and motor reaction levels; it will greatly aid in the reduction of accidents by the use of these tests in selection and placement within industry.

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APPENDIX

Instructions for Administering

Test I

This is a test to see how well you can sort blocks. The blocks are to be sorted according to the number of black spots they have on their sides. You are to pick up two blocks at a time, one in each hand, and inspect them on all sides for these black spots. If a block has one spot throw it into box labeled I. If there are two black spots on the block throw it into box II. If there are no black spots on the block, throw it into the box labeled none. Both accuracy and speed are important. Be certain to work as fast as you can without making mistakes. Do you have any questions? Ready. Go.

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Instructions for Administering

Test II

This is a test to see how quickly you can pack these blocks into this box. Do not pay any attention to the black spots. You may pick up as many blocks at a time as you wish. You may also pick them up in any way that you wish. Be certain to work as fast as you can, for speed in the only thing that counts. Do you have any questions? Ready. Go.

Instructions for Administering

Test II

This is a test to see how quickly you can pack these blocks into this box. Do not pay any attention to the size spots. You may pick up as many blocks at a time as you wish. You may also pick them up in any way that you wish. Be certain to work as fast as you can, for speed is the only thing that counts. Do you have any questions? Ready. Go.

Instructions for Administering
Tests III and VI

This is a test to see how quickly you can unscrew knobs. You are to use only your preferred hand and you may use your other hand to steady the board. Unscrew one knob at a time and throw it into this box. Do this until all knobs have been unscrewed and thrown into the box. Be certain to work as fast as you can, for speed is the only thing that counts. Do you have any questions? Ready. Go.

Instructions for Administering
Tests III and VI

This is a test to see how quickly you can unscrew knobs. You are to use only your preferred hand and you may use your other hand to steady the board. Unscrew one knob at a time and throw it into this box. Do this until all knobs have been unscrewed and thrown into the box. Be certain to work as fast as you can, for speed is the only thing that counts. Do you have any questions? Ready. Go.

Instructions for Administering
Test V

This is a test to see how well you can sort tubes. you are to pick up one tube at a time, using your preferred hand and inspect it on either end for a defect. The only defect you should look for is a round hole drilled in one side of the tube. (Demonstrate). If a tube has this defect throw it into the box labeled I. If there are no holes in the tube throw it into the compartment labeled NONE. Both accuracy and speed are important. Be certain to work as fast as you can without making mistakes. Do you have any questions? Ready. Go.

OFFICIENCY

RASE BOND

RAG CONTENT

Instructions for Administering
Tests IV and VII

This is a test to see how quickly you can screw these knobs to this board. You are to use only your preferred hand and you may use your other hand to steady the board. Pick up one knob at a time and screw it all the way onto the board. Repeat this operation until all knobs are screwed to the board. Be certain to work as fast as you can for speed in this test is the only thing that counts. Are there any questions? Ready. Go.

Instructions for Administering
Test VIII

This is a test to see how quickly you can pack thest blocks into this wooden tray. You may pick up as many blocks at a time as you wish. You may also pick them up in any way that you wish. Be certain to work as fas as you can, for speed is the only thing that counts. Do you have any questions? Ready. Go.

Date: March 11-51
March 18-51

ame: H. V. T.

Major: History

Minor: Economics

ex: male Age 21
arital Status single

41

ractures:

None

slocations:

None

lls: None

cidents: Length of time driving - 4 years
none

ngers caught in doors: 20 years, car door, not self inflicted
right index finger

prains: 20 years - right ankle, basket ball
21 years - left thumb, baseball

eep cuts: knife, ax, glass, wire-
None

urns: None

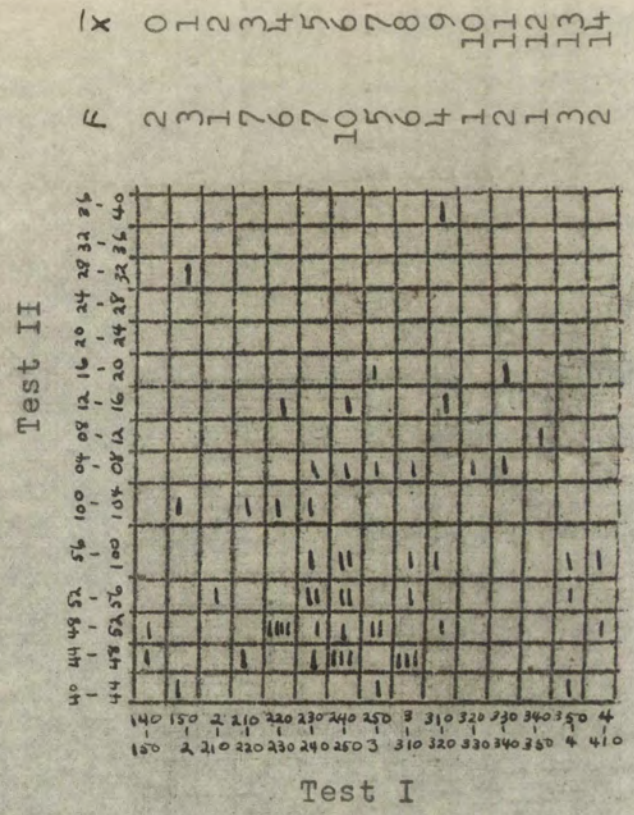
ead Blows: None

ody scars: operational scars

roken watch crystals: within last six months: one.

me on tests in minutes:

I. 2' 49.2"
II. 56.8"
II. 47.6"
IV. 1' 21.0"
V. 3' 51.1"
VI. 40.3"
II. 1' 18.6"
III. 1' 08.2"



F	$\bar{Y}$	ΣX
1	14	9
0	13	0
1	12	1
0	11	0
0	10	0
2	9	18
3	8	19
1	7	12
6	6	47
4	5	13
7	4	61
7	3	45
16	2	79
9	1	50
3	0	21

$\Sigma X = 375$

$\Sigma X^2 = 3039$

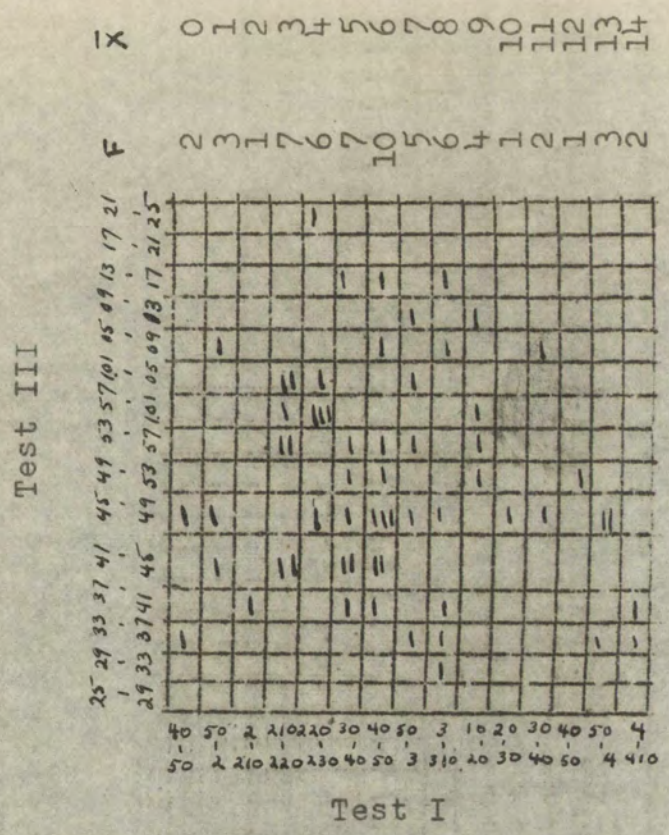
$\Sigma Y = 221$

$\Sigma Y^2 = 1307$

$\Sigma XY = 1318$

$\Sigma X \Sigma Y = 83250$

$r = -.1188$



F	$\bar{Y}$	ΣX
1	14	4
0	13	0
3	12	19
2	11	16
4	10	26
4	9	17
5	8	24
6	7	33
4	6	32
13	5	90
7	4	29
5	3	35
5	2	42
1	1	8
0	0	0

$\Sigma X = 375$

$\Sigma X^2 = 3039$

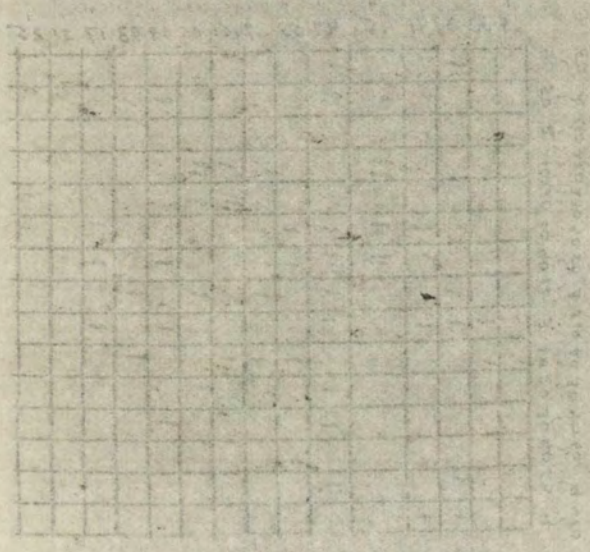
$\Sigma Y = 373$

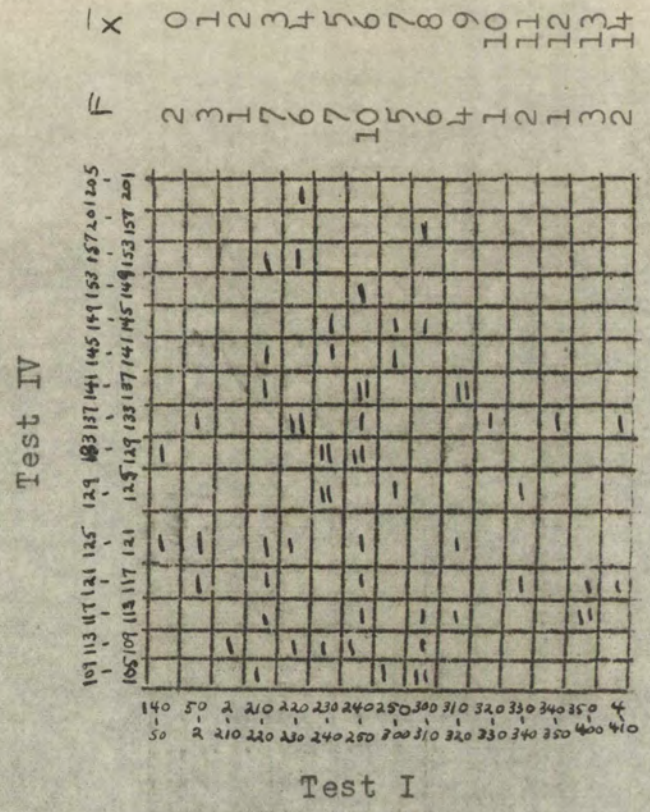
$\Sigma Y^2 = 2855$

$\Sigma XY = 2251$

$\Sigma X \Sigma Y = 139875$

$r = -.1314$





F	$\bar{Y}$	ΣX
1	14	4
1	13	8
2	12	7
1	11	6
3	10	20
3	9	15
5	8	33
7	7	51
5	6	21
4	5	28
6	4	23
7	3	55
6	2	52
5	1	25
4	0	26

$\Sigma X = 375$

$\Sigma X^2 = 3039$

$\Sigma Y = 320$

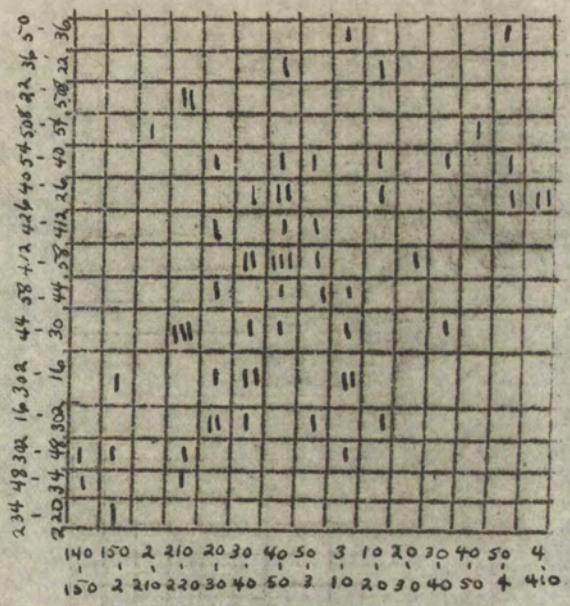
$\Sigma Y^2 = 2448$

$\Sigma XY = 1924$

$\Sigma X \Sigma Y = 120000$

$r = -.1058$

x	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
f	2	3	11	7	6	7	10	5	6	4	1	2	1	3	2



f	$\bar{y}$	Σx
2	14	21
2	13	15
2	12	6
2	11	14
6	10	50
7	9	67
3	8	17
7	7	45
4	6	25
7	5	39
6	4	31
5	3	29
4	2	12
2	1	3
1	0	1

$\Sigma x = 375$

$\Sigma x^2 = 3039$

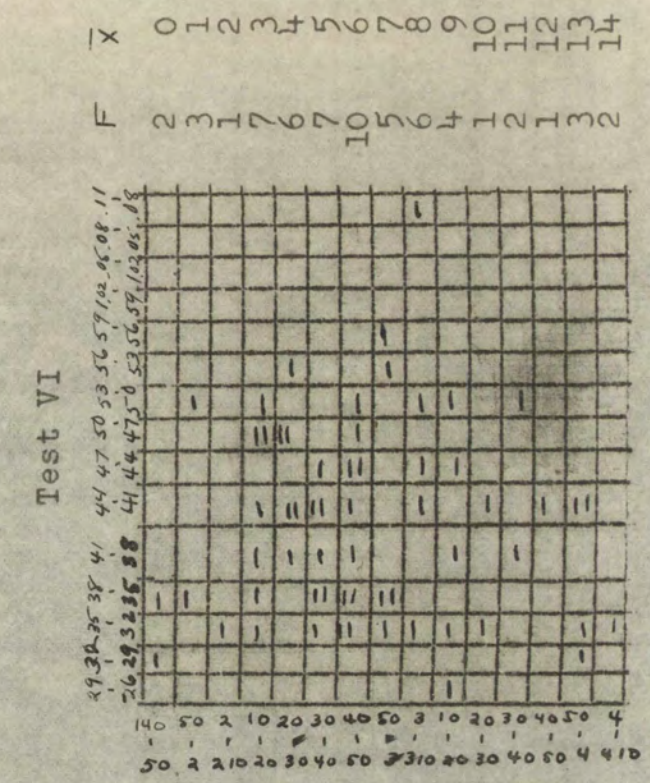
$\Sigma y = 404$

$\Sigma y^2 = 3440$

$\Sigma xy = 2852$

$\Sigma x \Sigma y = 151500$

$r = +.4622$



F	$\bar{Y}$	ΣX
1	14	8
0	13	0
0	12	0
0	11	0
1	10	7
2	9	11
6	8	38
5	7	20
5	6	34
11	5	83
6	4	38
9	3	40
10	2	73
2	1	14
2	0	9

$\Sigma x = 375$

$\Sigma x^2 = 3039$

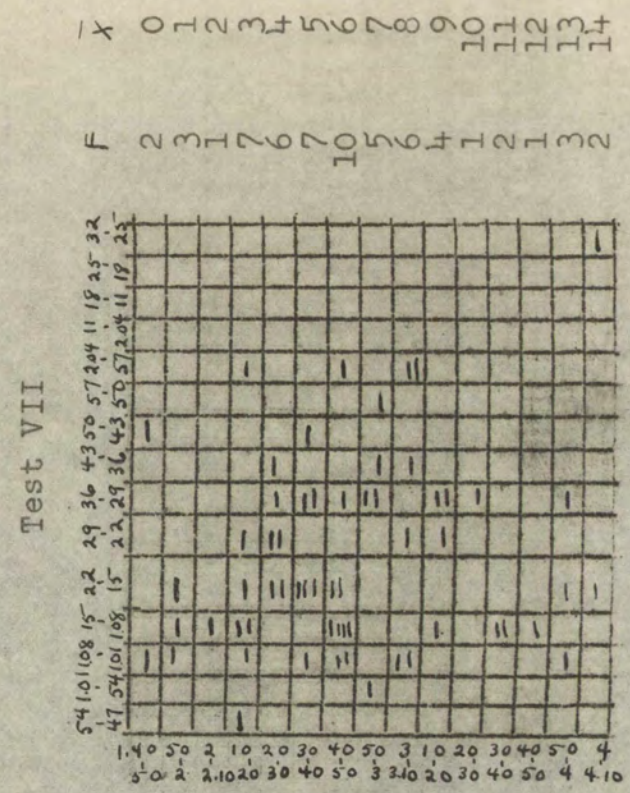
$\Sigma y = 283$

$\Sigma y^2 = 1761$

$\Sigma xy = 1776$

$\Sigma x \Sigma y = 106125$

$r = +.0133$



F	$\bar{Y}$	ΣX
1	14	14
0	13	0
0	12	0
0	11	0
4	10	25
1	9	7
2	8	5
3	7	19
10	6	75
5	5	28
11	4	66
12	3	76
9	2	50
1	1	7
1	0	3

$\Sigma X = 375$

$\Sigma X^2 = 3039$

$\Sigma Y = 284$

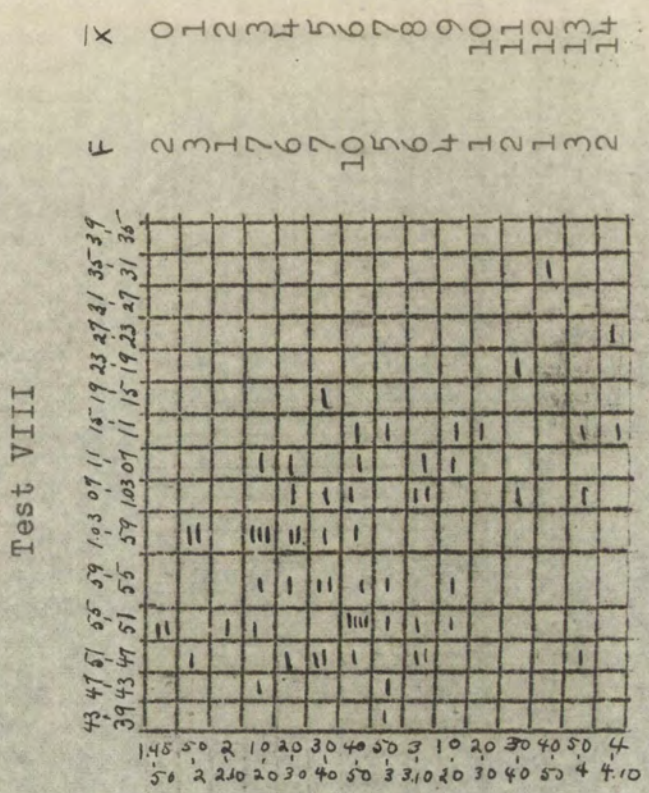
$\Sigma Y^2 = 1758$

$\Sigma XY = 1871$

$\Sigma X \Sigma Y = 106500$

$r = \pm .1789$

Test VIII



Test I

F	$\bar{y}$	Σx
0	14	0
1	13	12
0	12	0
1	11	14
1	10	11
1	9	5
6	8	59
5	7	30
7	6	55
9	5	30
7	4	39
11	3	53
8	2	50
2	1	10
1	0	7

Σx = 375

Σx^2 = 3039

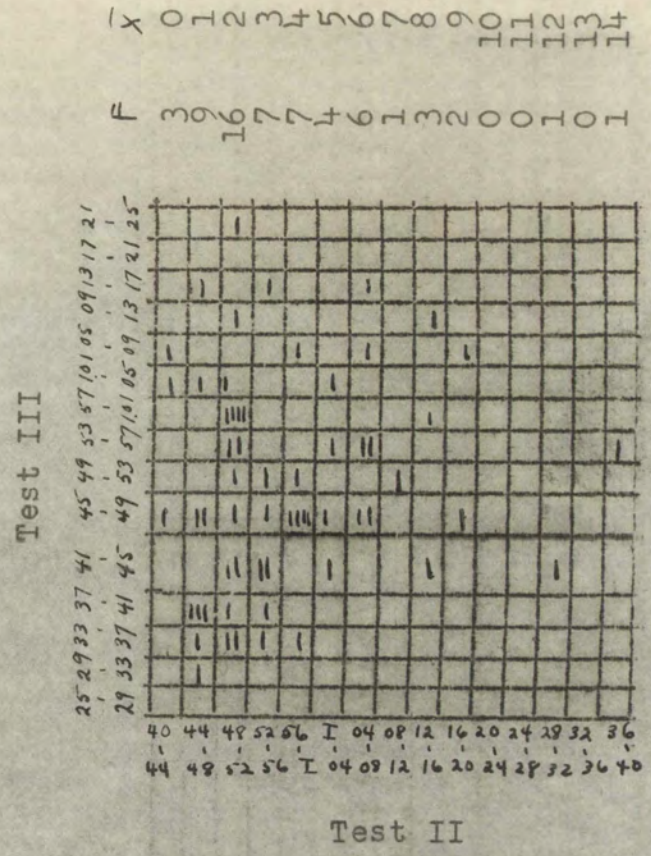
Σy = 292

Σy^2 = 1822

Σxy = 2052

$\Sigma x \Sigma y$ = 109500

r = +.4299



F	$\bar{y}$	Σx
1	14	2
0	13	0
3	12	10
2	11	10
4	10	19
4	9	8
5	8	16
6	7	35
4	6	16
13	5	49
7	4	35
5	3	8
5	2	12
1	1	1
0	0	0

$\Sigma x = 221$

$\Sigma x^2 = 1307$

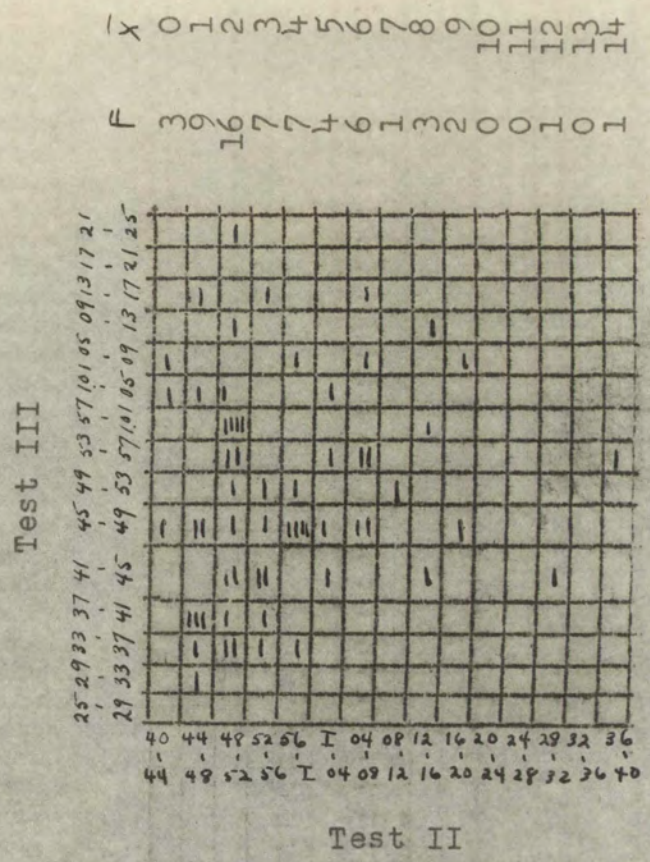
$\Sigma y = 373$

$\Sigma y^2 = 2855$

$\Sigma xy = 1423$

$\Sigma x \Sigma y = 82433$

$r = +.0955$



F	$\bar{y}$	Σx
1	14	2
0	13	0
3	12	10
2	11	10
4	10	19
4	9	8
5	8	16
6	7	35
4	6	16
13	5	49
7	4	35
5	3	8
5	2	12
1	1	1
0	0	0

$\Sigma x = 221$

$\Sigma x^2 = 1307$

$\Sigma y = 373$

$\Sigma y^2 = 2855$

$\Sigma xy = 1423$

$\Sigma x \Sigma y = 82433$

$r = +.0955$

F	$\bar{y}$	Σx
1	14	2
1	13	6
2	12	4
1	11	6
3	10	13
3	9	8
5	8	17
7	7	45
5	6	15
4	5	24
6	4	16
7	3	21
6	2	25
5	1	13
4	0	6

$\Sigma X = 221$

$\Sigma x^2 = 1307$

$\Sigma y = 320$

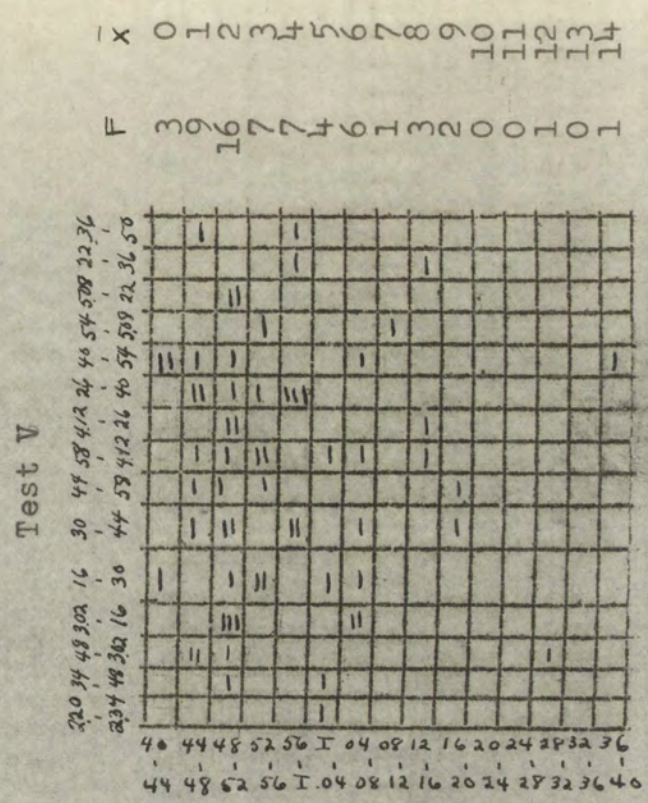
$\Sigma y^2 = 2448$

$\Sigma xy = 1273$

$\Sigma x \Sigma y = 70720$

$r = +.1560$

$$\Sigma x^2 = 551$$
$$\Sigma x^3 = 1304$$
$$\Sigma y^3 = 350$$
$$\Sigma x^4 = 3448$$
$$\Sigma xy = 1252$$
$$\Sigma x^2 y = 2950$$
$$\Sigma x^2 y^2 = 6824$$



F	$\bar{y}$	Σx
2	14	5
2	13	12
2	12	4
2	11	10
6	10	23
7	9	19
3	8	12
7	7	28
4	6	15
7	5	28
6	4	19
5	3	18
4	2	16
2	1	7
1	0	5

$\Sigma x = 221$

$\Sigma x^2 = 1307$

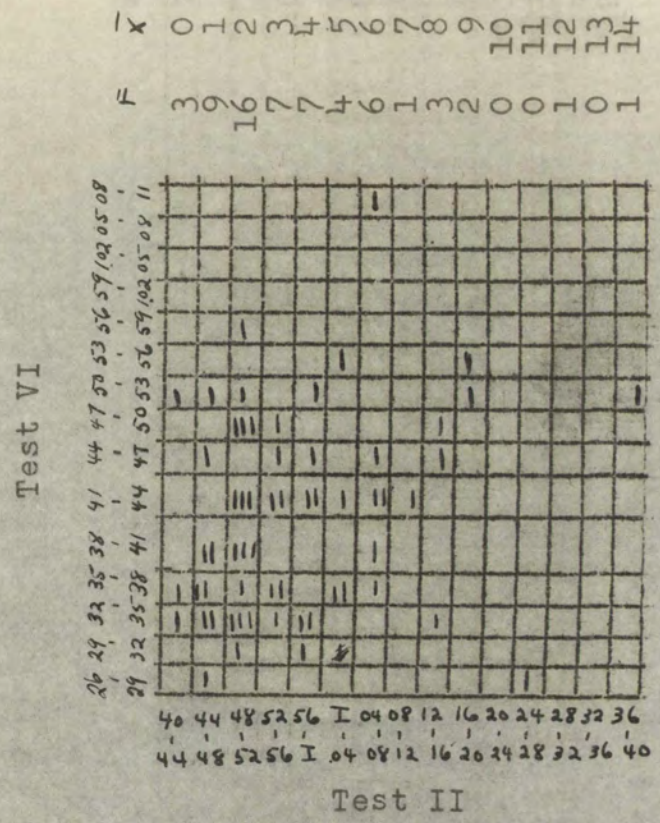
$\Sigma y = 404$

$\Sigma y^2 = 3440$

$\Sigma xy = 1476$

$\Sigma x \Sigma y = 89284$

$\sim = -.0225$



x	F
0	3
1	16
2	7
3	7
4	4
5	9
6	1
7	3
8	2
9	0
10	0
11	1
12	0
13	1
14	

F	$\bar{y}$	Σx
1	14	6
0	13	0
0	12	0
0	11	0
1	10	2
2	9	14
6	8	30
5	7	17
5	6	22
11	5	44
6	4	14
9	3	26
10	2	27
2	1	6
2	0	13

$\Sigma X = 221$

$\Sigma X^2 = 1307$

$\Sigma y = 283$

$\Sigma y^2 = 1761$

$\Sigma xy = 1175$

$\Sigma x \Sigma y = 62543$

$\sim = \pm .2893$

$\Sigma x = 551$

$\Sigma x^2 = 13051$

$\Sigma y = 583$

$\Sigma y^2 = 15951$

$\Sigma xy = 14511$

$r = \frac{n\Sigma xy - \Sigma x \Sigma y}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}} = 0.9243$

$= \frac{}{\sqrt{}}$

Test II

Test IV

F	$\bar{Y}$	ΣX
1	14	2
0	13	0
0	12	0
0	11	0
4	10	14
1	9	6
2	8	7
3	7	17
10	6	50
5	5	9
11	4	56
12	3	41
9	2	16
1	1	2
1	0	2

$\Sigma X = 221$

$\Sigma X^2 = 1307$

$\Sigma Y = 284$

$\Sigma Y^2 = 1758$

$\Sigma XY = 1107$

$\Sigma X \Sigma Y = 62764$

$r = +.1349$

Σx = 551

Σx^2 = 1301

Σx^3 = 5841

Σx^4 = 27128

Σx^5 = 130171

$\Sigma x^2 y$ = 25767

$\Sigma x^3 y$ = 120159

$\Sigma x^4 y$ = 562107

$\Sigma x^5 y$ = 2636455

$\Sigma x^6 y$ = 12374151

$\Sigma x^7 y$ = 58172599

$\Sigma x^8 y$ = 273660135

$\Sigma x^9 y$ = 1288000263

$\Sigma x^{10} y$ = 6064000551

$\Sigma x^{11} y$ = 28560002601

$\Sigma x^{12} y$ = 134480012351

$\Sigma x^{13} y$ = 633280058151

$\Sigma x^{14} y$ = 2982400273959

$\Sigma x^{15} y$ = 14043201290151

$\Sigma x^{16} y$ = 66130806076551

$\Sigma x^{17} y$ = 311414428360359

$\Sigma x^{18} y$ = 1466628000699751

$\Sigma x^{19} y$ = 6906000329599751

$\Sigma x^{20} y$ = 32520001552799751

$\Sigma x^{21} y$ = 153144007313599751

$\Sigma x^{22} y$ = 721344034459199751

$\Sigma x^{23} y$ = 3397440162359199751

$\Sigma x^{24} y$ = 16000320764359199751

$\Sigma x^{25} y$ = 75361501599359199751

$\Sigma x^{26} y$ = 354921007535999199751

$\Sigma x^{27} y$ = 1671600035495999199751

$\Sigma x^{28} y$ = 7872000167199999199751

$\Sigma x^{29} y$ = 37080000787599999199751

$\Sigma x^{30} y$ = 174600003709199999199751

$\Sigma x^{31} y$ = 822240017459999999199751

$\Sigma x^{32} y$ = 3872640082199999999199751

$\Sigma x^{33} y$ = 18236160387599999999199751

$\Sigma x^{34} y$ = 85890561825999999999199751

$\Sigma x^{35} y$ = 404520645599999999999199751

$\Sigma x^{36} y$ = 1905120040199999999999199751

$\Sigma x^{37} y$ = 8972640189599999999999199751

$\Sigma x^{38} y$ = 42252960893199999999999199751

$\Sigma x^{39} y$ = 199000004199999999999999199751

$\Sigma x^{40} y$ = 937200019799999999999999199751

$\Sigma x^{41} y$ = 4413840093199999999999999199751

$\Sigma x^{42} y$ = 20787840439199999999999999199751

$\Sigma x^{43} y$ = 97896961993199999999999999199751

$\Sigma x^{44} y$ = 461040004699999999999999999199751

$\Sigma x^{45} y$ = 2171040022199999999999999999199751

$\Sigma x^{46} y$ = 10226880104599999999999999999199751

$\Sigma x^{47} y$ = 48160320493199999999999999999199751

$\Sigma x^{48} y$ = 226800001599999999999999999999199751

$\Sigma x^{49} y$ = 1068000007599999999999999999999199751

$\Sigma x^{50} y$ = 5031600035599999999999999999999199751

$\Sigma x^{51} y$ = 23698560167199999999999999999999199751

$\Sigma x^{52} y$ = 111600000787599999999999999999999199751

$\Sigma x^{53} y$ = 525600003709199999999999999999999199751

$\Sigma x^{54} y$ = 2475360017459999999999999999999999199751

$\Sigma x^{55} y$ = 11659200082199999999999999999999999199751

$\Sigma x^{56} y$ = 54918720387599999999999999999999999199751

$\Sigma x^{57} y$ = 258653761825999999999999999999999999199751

$\Sigma x^{58} y$ = 1218361925599999999999999999999999999199751

$\Sigma x^{59} y$ = 5738880040199999999999999999999999999199751

$\Sigma x^{60} y$ = 27033600189599999999999999999999999999199751

$\Sigma x^{61} y$ = 127339200893199999999999999999999999999199751

$\Sigma x^{62} y$ = 599760000199999999999999999999999999999199751

$\Sigma x^{63} y$ = 2825040009399999999999999999999999999999199751

$\Sigma x^{64} y$ = 13305840043999999999999999999999999999999199751

$\Sigma x^{65} y$ = 62673600206999999999999999999999999999999199751

$\Sigma x^{66} y$ = 295214400973599999999999999999999999999999199751

$\Sigma x^{67} y$ = 1390560004599199999999999999999999999999999199751

$\Sigma x^{68} y$ = 6550080021599999999999999999999999999999999199751

$\Sigma x^{69} y$ = 30855360101599999999999999999999999999999999199751

$\Sigma x^{70} y$ = 145353600479199999999999999999999999999999999199751

$\Sigma x^{71} y$ = 684720002259199999999999999999999999999999999199751

$\Sigma x^{72} y$ = 3225120010599999999999999999999999999999999999199751

$\Sigma x^{73} y$ = 15193920049599999999999999999999999999999999999199751

$\Sigma x^{74} y$ = 71568000233999999999999999999999999999999999999199751

$\Sigma x^{75} y$ = 337104001099999999999999999999999999999999999999199751

$\Sigma x^{76} y$ = 1588080005199999999999999999999999999999999999999199751

$\Sigma x^{77} y$ = 7480320024599999999999999999999999999999999999999199751

$\Sigma x^{78} y$ = 35240640116199999999999999999999999999999999999999199751

$\Sigma x^{79} y$ = 166000000549199999999999999999999999999999999999999199751

$\Sigma x^{80} y$ = 781920002599199999999999999999999999999999999999999199751

$\Sigma x^{81} y$ = 3683040012199999999999999999999999999999999999999999199751

$\Sigma x^{82} y$ = 17349120057599999999999999999999999999999999999999999199751

$\Sigma x^{83} y$ = 81729600271199999999999999999999999999999999999999999199751

$\Sigma x^{84} y$ = 384960001279199999999999999999999999999999999999999999199751

$\Sigma x^{85} y$ = 1813440006039199999999999999999999999999999999999999999199751

$\Sigma x^{86} y$ = 8543040028399199999999999999999999999999999999999999999199751

$\Sigma x^{87} y$ = 40248960133599199999999999999999999999999999999999999999199751

$\Sigma x^{88} y$ = 189600000629199999999999999999999999999999999999999999999199751

$\Sigma x^{89} y$ = 893280002959199999999999999999999999999999999999999999999199751

$\Sigma x^{90} y$ = 4208640013999199999999999999999999999999999999999999999999199751

$\Sigma x^{91} y$ = 19828320065999199999999999999999999999999999999999999999999199751

$\Sigma x^{92} y$ = 93408000309999199999999999999999999999999999999999999999999199751

$\Sigma x^{93} y$ = 440064001459999199999999999999999999999999999999999999999999199751

$\Sigma x^{94} y$ = 2073120006899999199999999999999999999999999999999999999999999199751

$\Sigma x^{95} y$ = 9766560032399999199999999999999999999999999999999999999999999199751

$\Sigma x^{96} y$ = 46008960152199999199999999999999999999999999999999999999999999199751

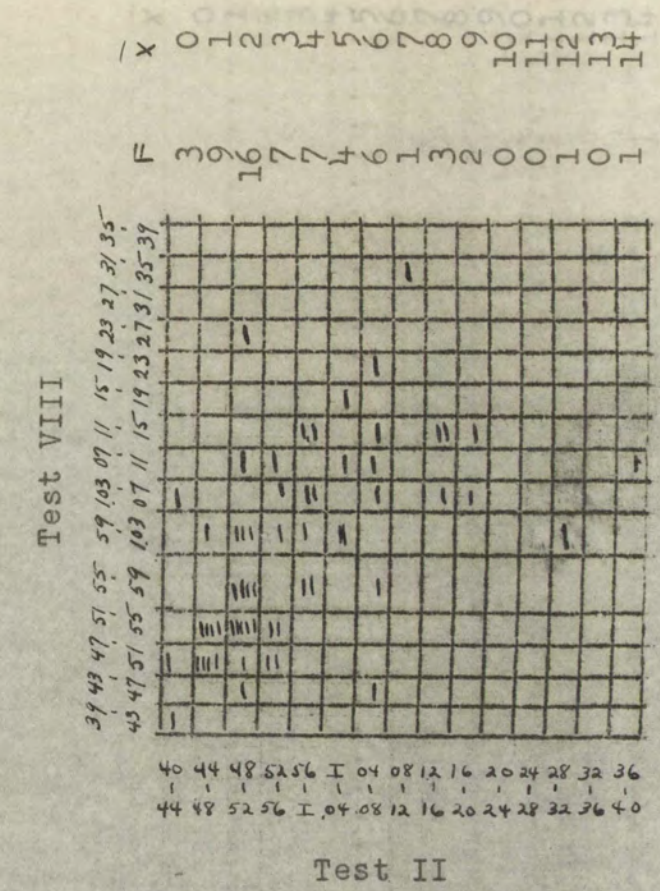
$\Sigma x^{97} y$ = 216720000719199999199999999999999999999999999999999999999999999199751

$\Sigma x^{98} y$ = 1020960003399199999199999999999999999999999999999999999999999999199751

$\Sigma x^{99} y$ = 4809600016099199999199999999999999999999999999999999999999999999199751

$\Sigma x^{100} y$ = 22656000075599199999199999999999999999999999999999999999999999999199751

Test II



F	$\bar{y}$	Σx
0	14	0
1	13	7
0	12	0
1	11	2
1	10	6
1	9	5
6	8	39
5	7	30
7	6	34
9	5	36
7	4	22
11	3	19
8	2	12
2	1	8
1	0	0

$\Sigma x = 221$

$\Sigma x^2 = 1307$

$\Sigma y = 292$

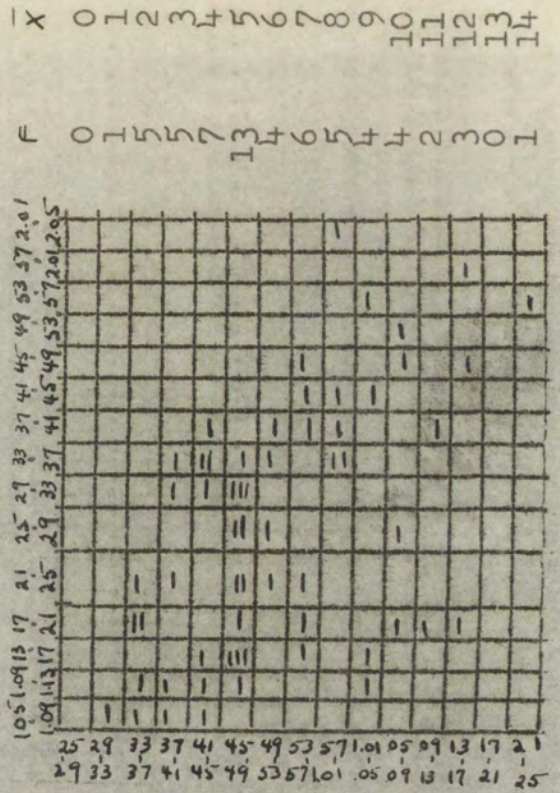
$\Sigma y^2 = 1822$

$\Sigma xy = 1301$

$\Sigma x \Sigma y = 64532$

$r = +.5071$

Test IV



Test III

F	$\bar{y}$	Σx
1	14	8
1	13	12
2	12	23
1	11	10
3	10	29
3	9	24
5	8	36
7	7	38
5	6	22
4	5	26
5	4	28
7	3	49
5	2	35
5	1	23
4	0	10

$\Sigma x = 373$

$\Sigma x^2 = 2855$

$\Sigma y = 320$

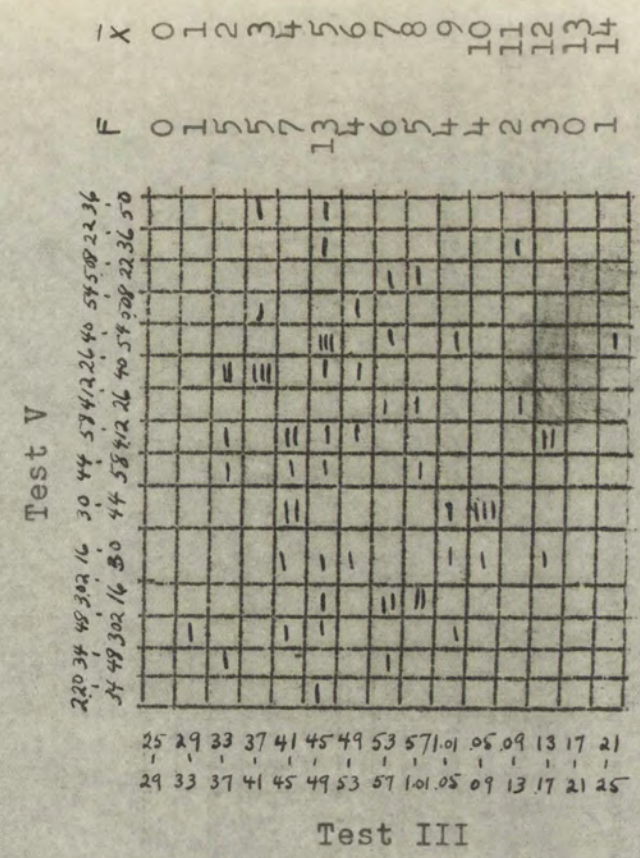
$\Sigma y^2 = 2448$

$\Sigma xy = 2328$

$\Sigma x \Sigma y = 119360$

$r = +.5371$

Test III



F	Y	ΣX
2	14	8
2	13	16
2	12	15
2	11	9
6	10	45
7	9	24
3	8	26
7	7	45
4	6	19
7	5	52
6	4	46
5	3	35
4	2	19
2	1	9
1	0	5

$\Sigma X = 373$

$\Sigma X^2 = 2855$

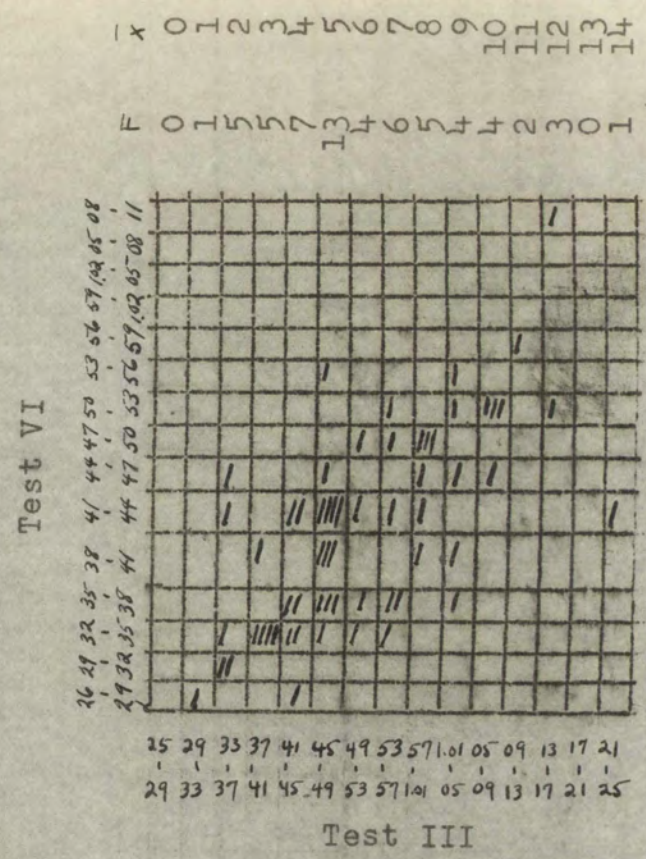
$\Sigma Y = 404$

$\Sigma Y^2 = 3404$

$\Sigma XY = 2498$

$\Sigma X \Sigma Y = 150692$

$r = -.0211$



F	$\bar{y}$	ΣX
1	14	12
0	13	0
0	12	0
0	11	0
1	10	11
2	9	14
6	8	58
5	7	37
5	6	40
11	5	65
6	4	35
9	3	52
10	2	40
2	1	4
2	0	5

$\Sigma x = 373$

$\Sigma x^2 = 2855$

$\Sigma y = 283$

$\Sigma y^2 = 1761$

$\Sigma xy = 2072$

$\Sigma x \Sigma y = 105559$

$r = +.6541$

$$\Sigma x = 313$$

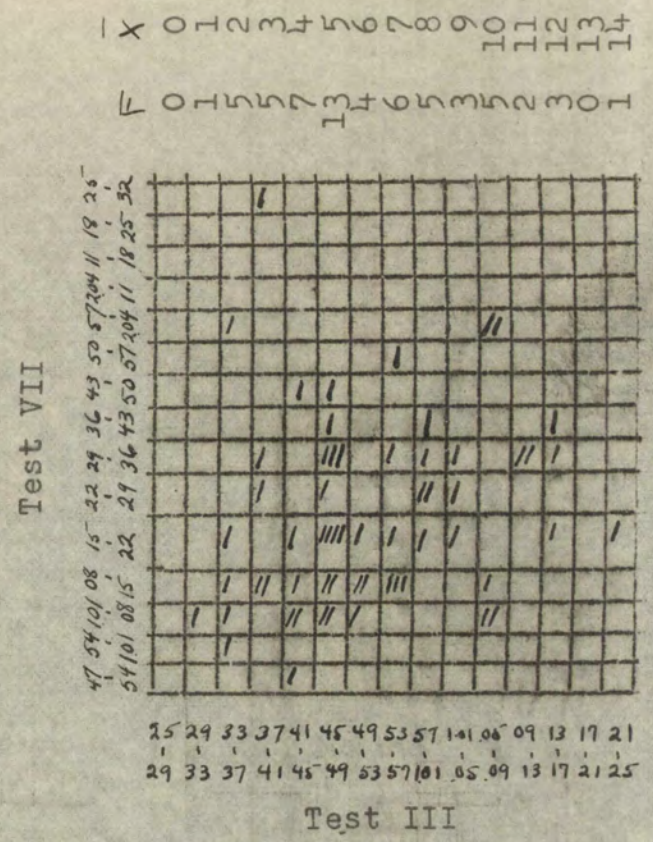
$$\Sigma x^2 = 5822$$

$$\Sigma y = 583$$

$$\Sigma y^2 = 1741$$

$$\Sigma xy = 1015$$

$$N = 4 \quad \Sigma x \Sigma y = 182279$$



F	$\bar{Y}$	ΣX
1	14	3
0	13	6
0	12	0
0	11	0
4	10	26
1	9	7
2	8	9
3	7	25
10	6	76
5	5	33
11	4	77
12	3	65
9	2	47
1	1	2
1	0	4

$\Sigma x = 373$

$\Sigma x^2 = 2855$

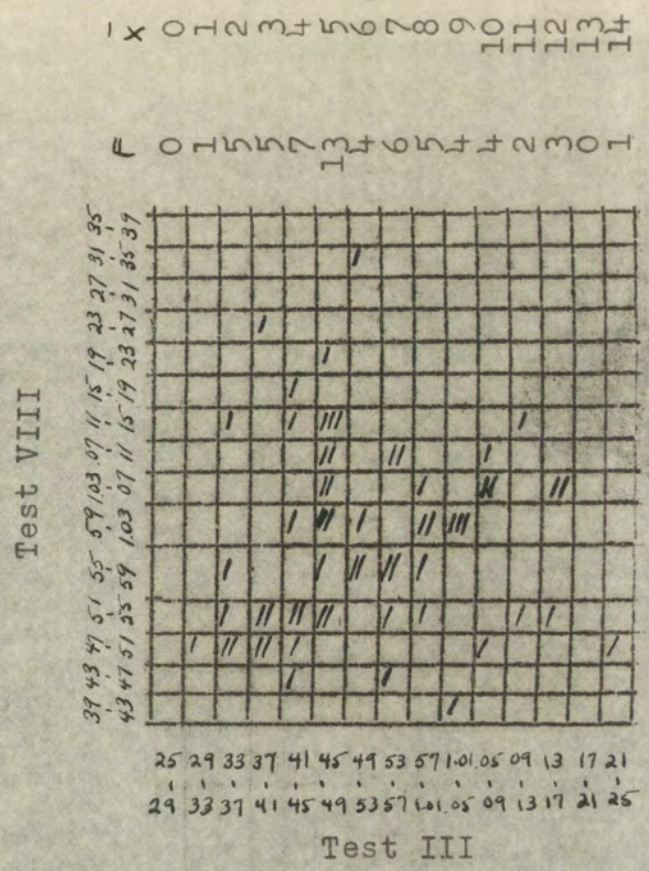
$\Sigma y = 284$

$\Sigma y^2 = 1758$

$\Sigma xy = 1832$

$\Sigma x \Sigma y = 105932$

$r = +.1411$



F	$\bar{y}$	Σx
0	14	0
1	13	6
0	12	0
1	11	3
1	10	5
1	9	4
6	8	32
5	7	34
7	6	62
9	5	63
7	4	41
11	3	64
8	2	39
2	1	11
1	0	9

$\Sigma x = 373$

$\Sigma x^2 = 2855$

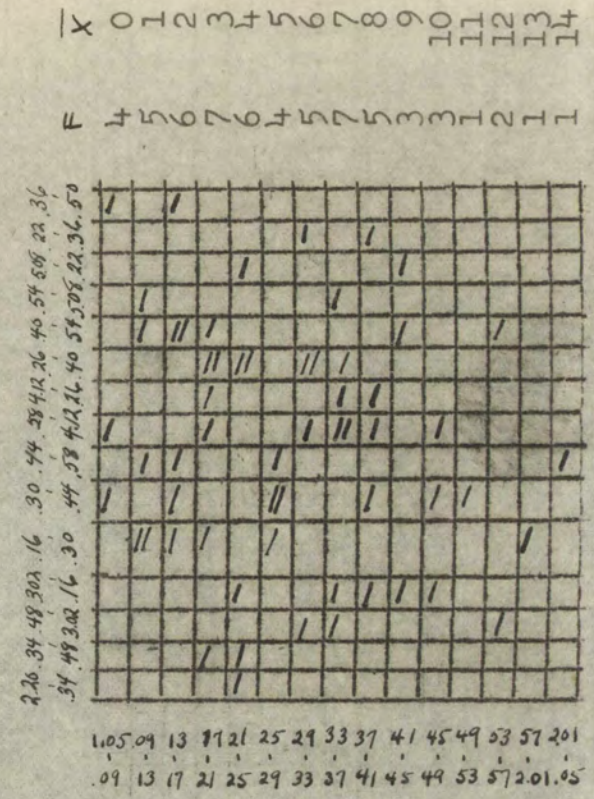
$\Sigma y = 292$

$\Sigma y^2 = 1822$

$\Sigma xy = 1823$

$\Sigma x \Sigma y = 108916$

$r = +.0166$



F	$\bar{Y}$	ΣX
2	14	2
2	13	14
2	12	13
2	11	8
6	10	29
7	9	33
3	8	18
7	7	41
4	6	22
7	5	41
6	4	25
5	3	38
4	2	25
2	1	7
1	0	4

$\Sigma x = 320$

$\Sigma x^2 = 2448$

$\Sigma y = 404$

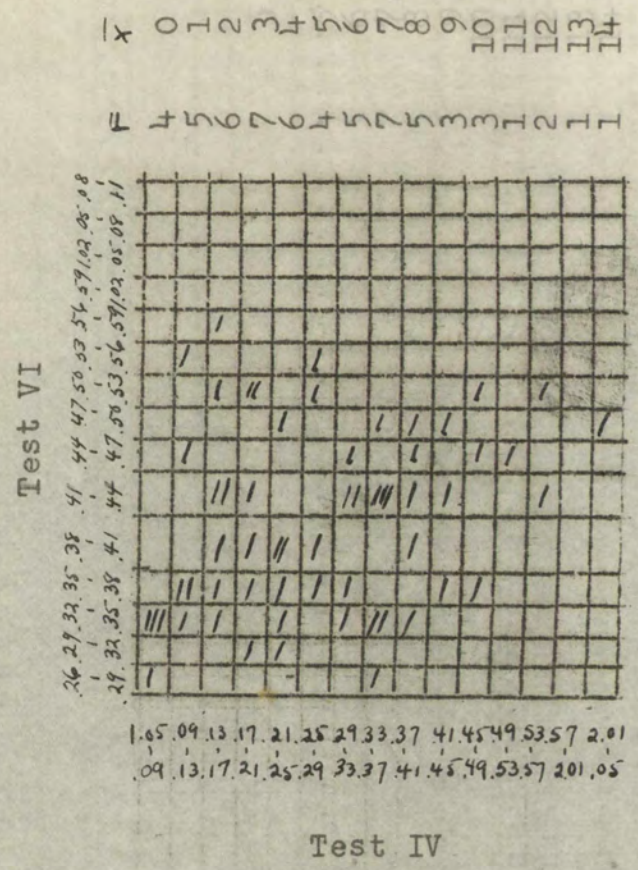
$\Sigma y^2 = 3440$

$\Sigma xy = 2080$

$\Sigma x \Sigma y = 129280$

$r = -.1022$

| | | |



F	$\bar{y}$	Σx
1	14	13
0	13	0
0	12	0
0	11	0
1	10	3
2	9	6
6	8	35
5	7	42
5	6	36
11	5	69
6	4	26
9	3	41
10	2	35
2	1	7
2	0	7

$\Sigma x = 320$

$\Sigma x^2 = 2448$

$\Sigma y = 283$

$\Sigma y^2 = 1761$

$\Sigma xy = 1705$

$\Sigma x \Sigma y = 90560$

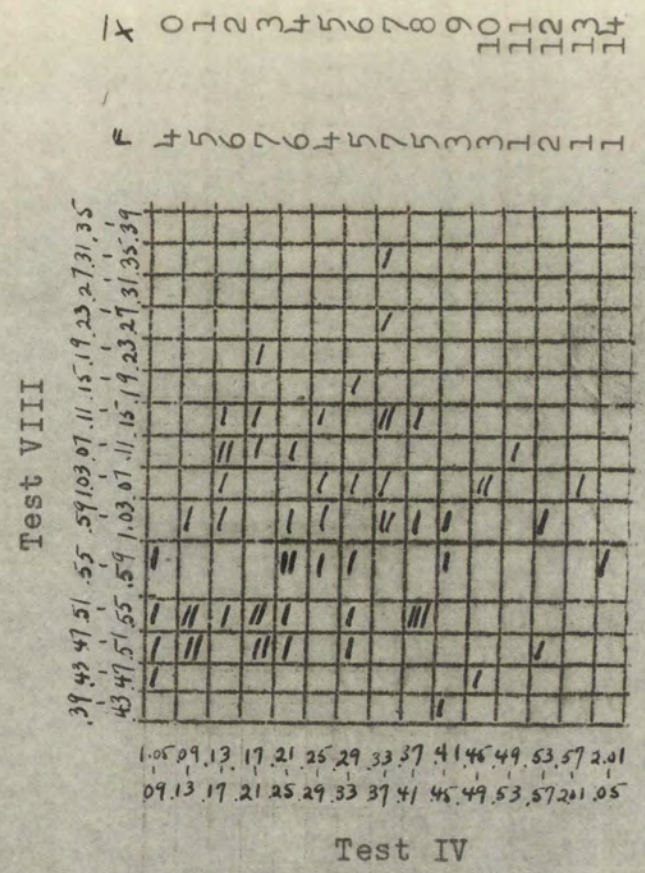
$r = +.3479$

x^4	350
x^3y	8448
x^2y^2	8484
xy^3	8712
y^4	8910
x^3	8800
x^2y	8844
xy^2	8778
y^3	8580

Test IV

Test IIV

x	
14	
13	
12	
11	
10	
9	
8	
7	
6	
5	
4	
3	
2	
1	
0	



F	$\bar{Y}$	ΣX
0	14	0
1	13	7
0	12	0
1	11	7
1	10	3
1	9	6
6	8	32
5	7	22
7	6	53
9	5	55
7	4	42
11	3	44
8	2	30
2	1	10
1	0	9

$\Sigma X = 320$

$\Sigma X^2 = 2448$

$\Sigma Y = 292$

$\Sigma Y^2 = 1822$

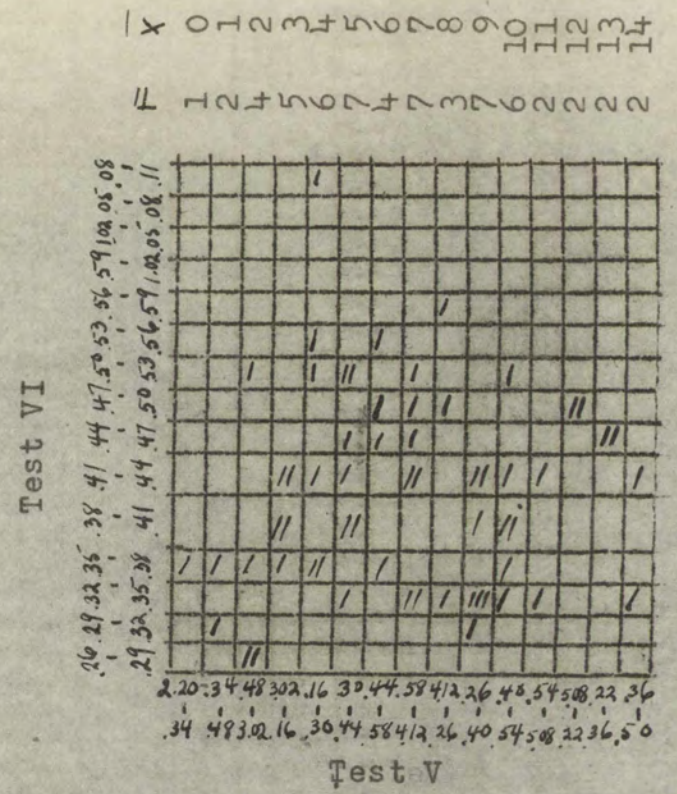
$\Sigma XY = 1625$

$\Sigma X \Sigma Y = 93440$

$r = +.1241$

Test VIII

VI Test



F	$\bar{Y}$	ΣX
1	14	4
0	13	0
0	12	0
0	11	0
1	10	8
2	9	10
6	8	33
5	7	47
5	6	44
11	5	82
7	4	45
8	3	30
10	2	89
2	1	10
2	0	2

$\Sigma x = 404$

$\Sigma x^2 = 3440$

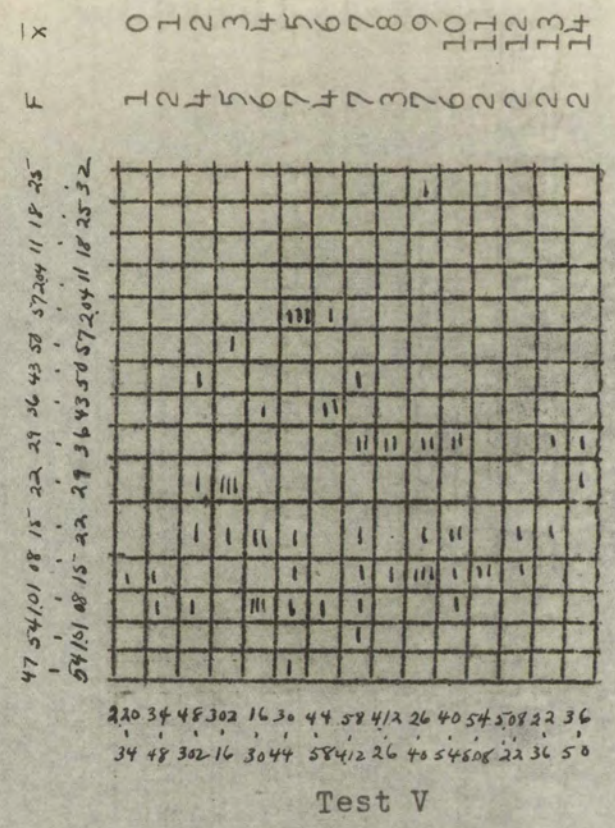
$\Sigma y = 283$

$\Sigma y^2 = 1761$

$\Sigma xy = 1951$

$\Sigma x \Sigma y = 114332$

$r = +.0820$



F	$\bar{y}$	Σx
1	14	9
0	13	0
0	12	0
0	11	0
4	10	21
1	9	3
2	8	9
3	7	20
10	6	95
5	5	25
11	4	75
12	3	93
9	2	42
1	1	7
1	0	5

$\Sigma x = 404$

$\Sigma x^2 = 3440$

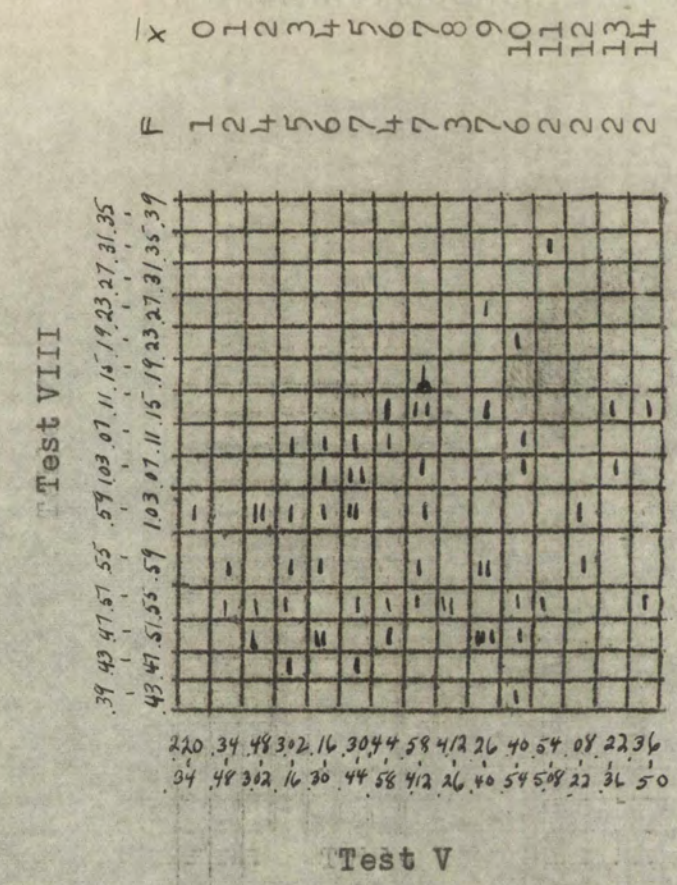
$\Sigma y = 284$

$\Sigma y^2 = 1758$

$\Sigma xy = 1940$

$\Sigma x \Sigma y = 114736$

$r = +.0355$



F	$\bar{y}$	Σx
0	14	0
1	13	11
0	12	0
1	11	9
1	10	10
1	9	7
6	8	36
5	7	28
7	6	52
9	5	40
7	4	45
11	3	75
8	2	53
2	1	8
1	0	10

$\Sigma x = 404$

$\Sigma x^2 = 3440$

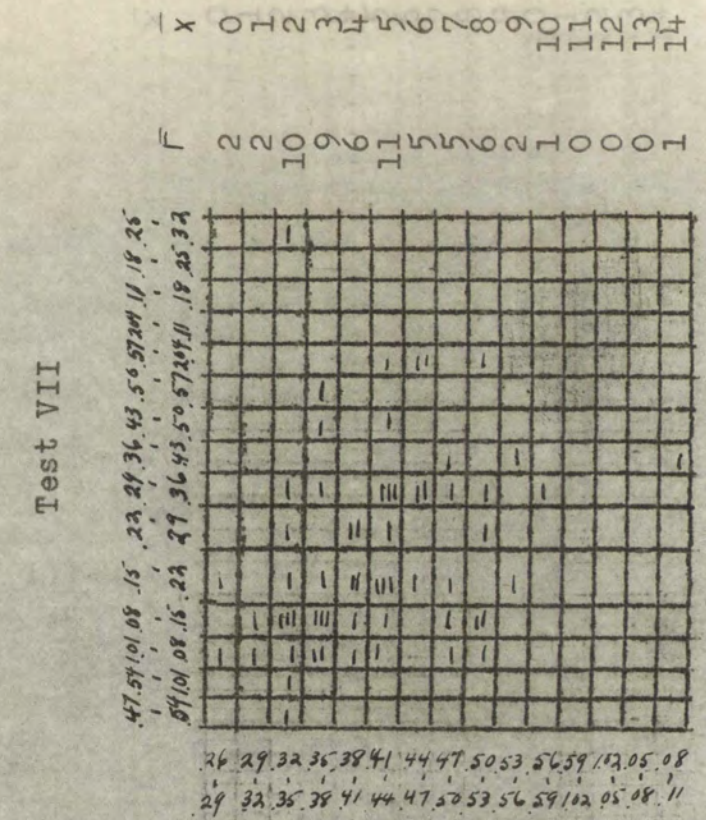
$\Sigma y = 292$

$\Sigma y^2 = 1822$

$\Sigma xy = 2080$

$\Sigma x \Sigma y = 117968$

$r = +.2219$



F	$\bar{Y}$	ΣX
1	14	2
0	13	0
0	12	0
0	11	0
4	10	25
1	9	3
2	8	8
3	7	30
10	6	57
5	5	23
11	4	50
12	3	48
9	2	33
1	1	2
1	0	2

$\Sigma X = 283$

$\Sigma X^2 = 1761$

$\Sigma XY = 284$

$\Sigma Y^2 = 1758$

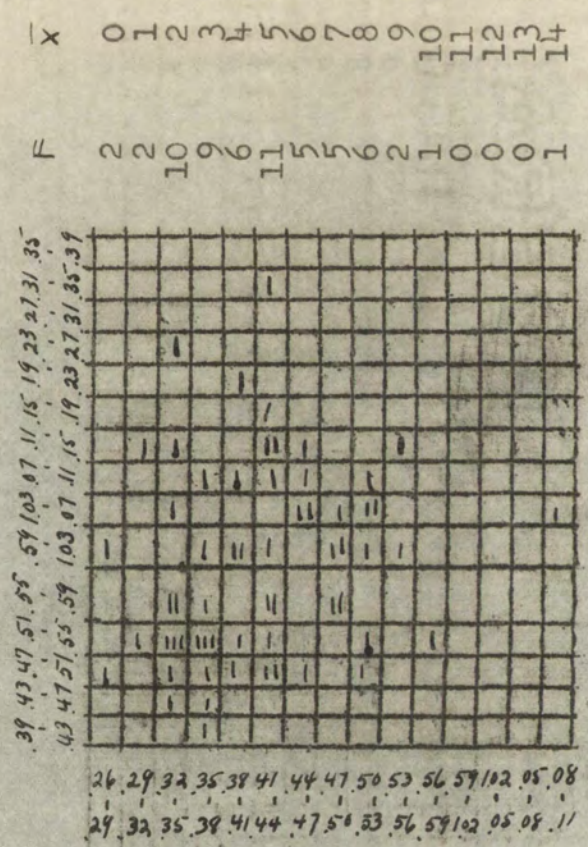
$\Sigma XY = 1448$

$\Sigma X \Sigma Y = 80372$

$r = +.2583$

Test IV

Test VII



F	$\bar{y}$	Σx
0	14	0
1	13	5
0	12	0
1	11	2
1	10	4
1	9	5
6	8	28
5	7	26
7	6	51
9	5	47
7	4	31
11	3	43
8	2	33
2	1	5
1	0	3

$\Sigma x = 283$

$\Sigma x^2 = 1761$

$\Sigma y = 292$

$\Sigma y^2 = 1822$

$\Sigma xy = 1443$

$\Sigma x \Sigma y = 82636$

$r = +.1590$

F	$\bar{y}$	Σx
0	14	0
1	13	3
0	12	0
1	11	14
1	10	4
1	9	8
6	8	32
5	7	26
7	6	38
9	5	33
7	4	28
11	3	50
8	2	33
2	1	9
1	0	6

$\Sigma x = 284$

$\Sigma x^2 = 1758$

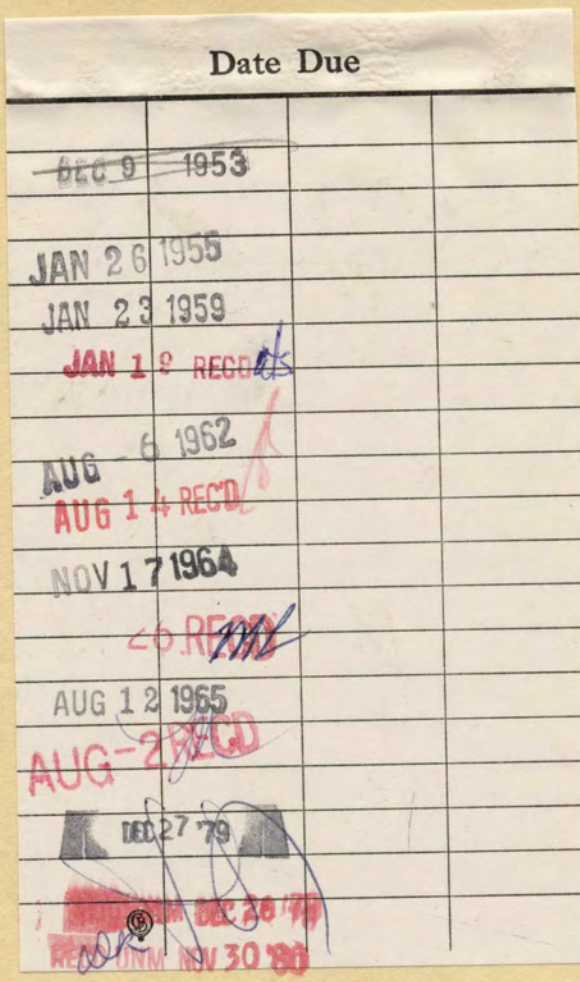
$\Sigma y = 292$

$\Sigma y^2 = 1822$

$\Sigma xy = 1473$

$\Sigma x \Sigma y = 82928$

$\sim = \pm .2231$



IMPORTANT!

Special care should be taken to prevent loss or damage of this volume. If lost or damaged, it must be paid for at the current rate of typing.