PERCEPTUAL-MOTOR SPEED DISCREPANCY AND DEVIANT DRIVING

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James A. Clark

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PERCEPTUAL-MOTOR SPEED DISCREPANCY AND DEVIANT DRIVING

BY

JAMES A. CLARK

A THESIS

Submitted to the College of Science and Arts
Michigan State University of Agriculture and
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Department of Psychology

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AN ABSTRACT

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ABSTRACT

In 1940, Drake offered the following hypothesis on the basis of research with accidents in an industrial setting: Individuals who perform faster on motor tasks than on perceptual tasks tend to have more accidents than individuals with faster perceptual than motor speed. The present research attempted to extend Drake's hypothesis regarding "perceptual-motor speed discrepancy" into the area of traffic accidents.

The basic pool of subjects consisted of 199 drivers. Of this total, 106 were classified as problem drivers primarily due to high violation records, and 93 were applicants for routine renewals of their driving permits. In forming a problem-driver and a control group, an attempt was made to (a) equate the two groups for age, education, vocabulary level, and weekly mileage, (b) approximate the distribution of ages of the male drivers in Michigan, and (c) maximize the difference between the groups for accidents. This procedure led to final groups of 70 subjects each.

All subjects were administered three perceptual speed and three motor speed tests. Included in the battery were the pair

of perceptual and motor tests offering the best predictions in Drake's research. The score for each test was the total time to complete two trials. Measures of perceptual-motor speed discrepancies were derived by subtracting individual performance on each motor test from each perceptual test (standard scores).

The results were clearly negative when the problem-driver and control groups were compared on perceptual-motor speed discrepancies, perceptual and motor speed per se, and variability from trial 1 to trial 2. In discussing the negative results, attention was drawn to (a) possible deficiencies in the present study and (b) the nature of Drake's hypothesis. The emphasis was placed on the faulty assumptions inherent in Drake's hypothesis.

Major Professor _____
Gerald F. King, Ph.D.

Date _____

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*"A" indicates the table is in the Appendix.

I. Introduction

Almost 20 years ago, Drake (1939-40) reported a study relating the incidence of accidents among female factory workers to scores on perceptual and motor speed tests. While the findings revealed no relationship between accident rate and either perceptual or motor speed per se, significant results were obtained with an analysis using the difference in performance on the two types of tests, what might be called "perceptual-motor speed discrepancy." Workers with high accident records performed relatively faster on the motor tasks than on the perceptual tasks, and conversely for the workers with low accident histories. On the basis of these results, Drake offered the following hypothesis: "Individuals whose level of muscular reaction is above their level of perception are prone to more frequent and more severe accidents than those individuals whose muscular reactions are below their perceptual level. In other words, the person who reacts quicker than he can perceive is more likely to have accidents than is the person who can perceive faster than he can react" (pp. 339-340).

Drake interpreted his results as having possible application beyond the accident behavior of factory workers, suggesting that the hypothesis might be used to predict accidents for individuals in other settings (e.g., bus drivers, airplane

pilots). While Drake's study has become a commonly cited reference in the subsequent literature on industrial and traffic safety (e.g., Maier, 1946; McFarland, Moore, and Warren, 1954; Tiffin, 1947), the author is not aware of any attempts either to replicate this study or to use its orientation for research in other contexts. The objective of the present study was to test Drake's hypothesis regarding perceptual-motor speed discrepancy in the area of traffic accidents.

II. Method

Perceptual and Motor Speed Tests

A number of factors were given consideration in assembling a battery of three perceptual and three motor speed tests. Included in the battery were the pair of perceptual and motor tests that yielded the best predictive discrepancy-score in Drake's study. The remaining four tests were selected or constructed on the basis of purity and variety. In regard to purity, an attempt was made to maximize the differences between the two types of tasks by using perceptual tests relatively free of motor components and motor tests with minimal perceptual involvement. Variety was most apparent in the motor tests, where the requirements ranged from small hand movements to gross arm movements. The score for each test was the number of seconds needed to complete the test. The following gives brief descriptions of the tests, with more details being available in Appendix A.

Perceptual tests. The materials for the Spiral Inspection Test (P-SI), one of Drake's tests, consisted of 50 spirals, 4½ inches long and 5/16 inch in diameter. Flat-wound from thin strips of steel ¼ inch wide, each spiral had a small circular hole punched in the flat surface of the coil. Half of the

spirals were standard, i.e., the holes were exactly 2½ turns from the ends of the spirals. The other half was classified as off-standard, with the placement of the holes varying from 1½ to 3½ turns from the ends. The task was to sort the standard and off-standard spirals into two separate piles. The number of errors (incorrectly placed spirals) was also recorded.

The Perceptual Scanning Test (P-PS) involved finding in order the numbers 1 through 35, which were randomly scattered on an 8 by 11 inch sheet of paper. As each number was located, it was tapped lightly with the eraser end of a pencil. Forms A and B were constructed for this test.

The Number Recognition Test (P-NR) consisted of 50 pairs of numbers in both Forms A and B. Opposite each pair of numbers were the letters "S" and "D". If the numbers were the same, S was underlined; if different, D was underlined. Number of errors provided an additional score.

Motor tests. In the Right-Right Turning Test (M-RT), another of Drake's tests, there was an upright panel (24 inches long and 12 inches high) with two rows of six right-turn bolts each. The task was to use both hands in turning the bolts, two at a time, until they were flush with the panel.

The Two-Plate Tapping Test (M-TT) used a horizontal board with a metal plate (3½ inches by 3½ inches) at each end. The

plates were 10-3/8 inches apart. Each tap with a stylus activated a counter through an electrical circuit. The task was to make 100 taps, alternately tapping the two plates.

From the Minnesota Rate of Manipulation Test (Educational Test Bureau, 1946), the Turning Subtest (M-RM) was selected. Using the standard form-board and set of 60 circular blocks, this test required the coordinated use of both hands. Each block was lifted with the lead hand and placed, bottom side up, in the same hole with the trailing hand.

Subjects

The basic pool of subjects (Ss) was comprised of 199 male, white drivers residing in the city of Detroit. Of this total, 106 were classified as "problem" drivers; 93 were controls. The former Ss were drivers who, due to an excessive number of violations and/or accidents, had been summoned by the Driver and Vehicle Services for a re-examination interview to determine their future driving privileges. They were tested as they waited for their interview appointments. The control Ss consisted of consecutive applicants for routine license renewals at a "representative" examining station (police precinct). A subsequent review of the Central Driver Files revealed that

only one control S was eligible for re-examination, and this S was eliminated.[1]

In forming a problem-driver and a control group, an attempt was made to (a) equate the two groups for age, education, and WAIS vocabulary level, (b) approximate the distribution of ages of the male drivers in the State of Michigan, and (c) maximize the difference between the groups for number of accidents (previous five years). This procedure led to final groups of 70 Ss each.

As can be seen in Table 1, the problem-driver and control groups were closely equated for age, education, and vocabulary. The difference between the groups on number of accidents, however, was very significant ($p < .01$), as the problem-driver group experienced more than four times as many accidents as the control group. It should also be mentioned that there was a difference between the groups on reported weekly mileage. The problem-driver group ($M = 445$, $SD = 404$) showed a trend toward higher level and were significantly more variable than the control group ($M = 368$, $SD = 279$). However, weekly mileage was not significantly correlated with either number of accidents or any of the perceptual and motor tests for the total N of 199 (see Appendix B).

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[1]Of all the drivers contacted, only 10 refused to serve as Ss.

Table 1

Comparison of the Problem-Driver (N=70) and Control (N=70) Groups on Age, Education, WAIS Vocabulary, and Accidents

Variables	Groups			
	Problem-Driver		Control	
	M	SD	M	SD
Age	39.01	13.23	39.54	13.12
Education	11.56	3.14	11.64	3.11
Vocabulary	9.33	3.00	9.67	2.88
Accidents[a]	1.70	1.56	0.41	0.57

[a]The difference between the groups for number of accidents was significant beyond the .01 level.

A comparison of the two groups with normative data for Michigan male drivers on age is given in Appendix C. A test of goodness of fit for the distributions yielded a nonsignificant chi square of 6.27 ($p > .90$).

Procedure

The Ss were tested individually by two examiners, one administering the perceptual tests as a block and the other the three motor tests. Within each block, the tests were given in the previously listed order. In the problem-driver group, 40 were given the perceptual tests first, while 33 underwent the perceptual tests first in the control group.[2] The Ss were given two trials on each of the six tests. Except for the P-PS, P-NR, and M-TT tests, the second trial was essentially a repetition of the first. Form B was used for P-PS and P-NR. For M-TT, S tapped with his preferred hand on the first trial and with his nonpreferred hand on the second. During the test situation, the Ss were interviewed and administered the WAIS vocabulary subtest. The following information was obtained from

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[2]No significant relationship was found between type of tests administered first and any of the personal variables (e.g., age, accidents) or task measures, the correlations ranging from -.115 to .077 ($N = 199$).

the interview: age, education, estimate of average weekly mileage, and estimate of number of accidents in the previous five years.[3]

In addition to explaining the nature of the task, the standard instructions for each test emphasized speed of performance (see Appendix A). Additional attempts to motivate S were made between trials, urging him to better his first-trial score.

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[3]The number of accidents reported by the Ss was checked by an examination of the Central Driver Files. The differences between the groups on accidents was upheld. In fact, the four-to-one ratio became closer to five-to-one.

III. Results

When the time scores for the perceptual and motor tests were plotted for each trial, there were no apparent deviations from normal distributions. For the preliminary analysis, scores were assigned to the Ss simply by summing the times for the two trials. The correlations between the first and second trials, which can be interpreted as minimal estimates of reliability, were as follows: P-SI, .73; P-PS, .73; P-NR, .92; M-RT, .88; M-TT, .77; M-RM, .86.

Preliminary Analysis

A factor analysis of the perceptual and motor scores, using the principal axis method and Guttman's (1958) method of estimating communalities, resulted in the isolation of two factors. Rotation by the quartimax method (Neuhaus and Wrigley, 1954) revealed a perceptual and a motor factor. All tests had higher loadings on their designated factors, although several tests (P-SI, M-TT, and M-RM) had sizeable loadings on both factors. In terms of differential loadings or purity, P-NR was the best perceptual test, M-RT the best motor test. The factor analysis is presented in more detail in Appendix D.

Possible differences in speed of performance were explored by comparing the problem-driver and control groups on all six

Table 2

Comparison of the Problem-Driver and Control Groups on Perceptual and Motor Speed (Number of Seconds)

	Groups				
	Problem-Driver		Control		
Tests	M	SD	M	SD	t
P-SI	395.0	89.1	406.0	87.0	0.74
P-PS	238.5	78.6	232.2	97.3	0.43
P-NP	357.9	117.8	363.8	124.7	0.28
M-RT	72.7	14.6	73.1	14.0	0.44
M-TT	49.4	6.9	51.3	6.0	1.73[a]
M-RM	116.8	21.9	155.2	14.9	0.50

[a] $p < .10$

tests. Table 3 shows that none of the t ratios were significant at the .05 level. The only significant difference between the groups was that the problem-driver group was more variable on M-RM. There was a general trend for the problem-driver group to perform faster and with more variability than the control group. Concurring with Drake's (1940) results, perceptual or motor speed per se was not found to be a significant variable.

The problem-driver and control groups were also compared on the number of errors incurred on P-SI and P-NR. None of the differences between the groups were significant. Appendix E provides more details for this analysis.

Major Analysis

In testing Drake's hypothesis, the first step was to derive measures of perceptual-motor speed discrepancies. After transforming performance on all tests to standard scores (following Drake's procedure), each motor speed score was subtracted from each perceptual speed score for all Ss. This procedure yielded nine discrepancy scores for each S. Since the measures were time scores, an S with a positive discrepancy score for a given pair of tests showed faster motor speed as compared to perceptual speed, and vice versa for a negative discrepancy score.

All Ss were classified as either "faster on perceptual performance" or "faster on motor performance" for each pair of tests. Then, fourfold tables were constructed, and tests of significance were conducted with chi square. A comparison of the problem-driver and control groups can be found in Table 3. Of the nine tests of significance, only one (P-SI vs. M-RM) was significant at the .05 level, and the difference was not in the predicted direction. One difference in the predicted direction, that derived from P-PS vs. M-TT, approached significance ($p < .10$). Both the differences from P-SI vs. M-RT, Drake's best pair of tests, and P-NR vs. M-RT, the best pair derived from factor analysis, were not in the predicted direction. In fact, five of the nine comparisons yielded differences in the opposite direction.

The problem-driver and control groups were also compared using the discrepancy scores instead of a dichotomy. High discrepancy scores reflect relatively faster motor speed than perceptual speed. None of the t ratios were significant. There were three significant F ratios (P-SI vs. M-RT, P-PS vs. M-RM, and P-NR vs. M-RM), two indicating greater variability for the problem-driver group and one for the control group. As would be expected, the pattern of differences was very similar to that

Table 3

Comparison of the Problem-Driver and Control Groups Using a Perceptual-Motor Speed Dichotomy: Chi Square Analysis

	Groups				
	Problem-Driver		Control		
Test Pairs	P[a]	M[a]	P	M	Chi Square
P-SI vs. M-RT	35	35	30	40	0.713
vs. M-TT	31	39	32	33	0.023
vs. M-RM	42	28	29	41	4.830[c]
P-PS vs. M-RT	33	37	34	36	0.029
vs. M-TT	29	41	40	30	3.458[b]
vs. M-RM	36	34	35	35	0.029
P-NR vs. M-RT	37	33	33	37	0.457
vs. M-TT	31	39	38	32	1.400
vs. M-RM	36	34	35	35	0.029

[a] P refers to faster on perceptual performance, M faster on motor performance.

[b] $p < .10$

[c] $p < .05$

found for the chi square analysis. Appendix F gives more details of this analysis.

Additional Analysis

The possibility of differences between the groups on variability from trial to trial was explored. For each S, the first trial was subtracted from the second trial (standard scores), and the absolute value of the differences was summed for the six tests. Table 4 presents a comparison of the problem-driver and control groups for this measure of variability. While the problem-driver Ss were slightly more variable than the control Ss, the trend did not approach statistical significance.

Table 4

Comparison of the Problem-Driver and Control Groups on Variability from Trial 1 to Trial 2

Measure of Variability	Groups		
	Problem-Driver	Control	*t*
M	78.12	74.84	0.562
SD	11.24	10.63	

IV. Discussion

The results failed to support an extension of Drake's hypothesis into the area of traffic accidents. Attention can be drawn to the following features of the present study which possibly contributed to the negative results: (a) the distinction between the problem-driver and control groups, and (b) the differences between the groups on level and variability of exposure.

When the distinction between the groups for accidents is examined, overlap is noted. Primarily high-violation drivers, nearly one-sixth of the Ss in the problem-driver group experienced no accidents, while on the other hand almost one-fifth of the control Ss were involved in at least one accident. It should be pointed out, however, that in an overall comparison the problem-driver Ss incurred more than four times as many accidents as the control Ss. While only the difference in variability was statistically significant, the problem-driver group tended both to drive more and to be more variable than the control group. Here, it can be mentioned that exposure was not found to be related to any of the perceptual and motor measures or to number of accidents.

Of seemingly more importance in accounting for the negative results is the nature of Drake's hypothesis. As stated, the hypothesis implicitly assumes that perceptual and motor speed are general abilities. The validity of these assumptions is doubtful in view of the results obtained by factor analytic studies investigating the components of perceptual performance (Roff, 1952) and motor performance (Fleishman, 1953). Research has indicated that, instead of general components, a multiplicity of factors underly perceptual and motor performance. If the hypothesis rests on faulty assumptions, an explanation might seem necessary for the positive findings obtained in an industrial setting. A possible reason for Drake's results is that he used perceptual and motor tasks that mirrored his Ss' work activities, the activities in which the accidents occurred. The hypothesis, as formulated, represents an overgeneralization.

Consideration might be given to a revision of Drake's hypothesis. The preceding discussion suggests that, as an alternative approach, the selection of tests could be guided by the nature of the activity under study. Thus, in predicting traffic accidents, the perceptual and motor tests would be selected on the basis of their relevance for driving behavior. Drake's notion about perceptual-motor speed discrepancies could be retested using this revised frame of reference.

V. Summary

On the basis of his investigations of industrial accidents, Drake formulated the following hypothesis: Individuals with high accident records perform relatively faster on motor tasks than on perceptual tasks, and conversely for individuals with low accident histories. As Drake interpreted his results as having possible application in other than industrial settings, the present research attempted to test his hypothesis regarding "perceptual-motor speed discrepancy" in the area of traffic accidents.

The basic pool of subjects consisted of 199 drivers. Of this total, 106 were classified as problem drivers primarily due to high violation records, and 93 were applicants for routine renewals of their driving permits. In forming a problem-driver and a control group, an attempt was made to (a) equate the two groups for age, education, vocabulary level, and weekly mileage, (b) approximate the distribution of ages of the male drivers in Michigan, and (c) maximize the difference between the groups for accidents. This procedure led to final groups of 70 subjects each.

All subjects were administered three perceptual speed and three motor speed tests. Included in the battery were the pair

of perceptual and motor tests offering the best predictions in Drake's research. The score for each test was the total time to complete two trials. Measures of perceptual-motor speed discrepancies were derived by subtracting individual performance on each motor test from each perceptual test (standard scores).

A comparison of the problem-driver and control groups on perceptual-motor speed discrepancies failed to produce the predicted differences. In addition, no substantial or consistent differences between the groups were obtained on either perceptual and motor speed per se or variability in performance from trial 1 to trial 2.

Possible deficiencies in the present research were pointed out, but their effects were minimized. The main emphasis, in accounting for the negative results, was on the nature of Drake's hypothesis. It was concluded that the hypothesis, by assuming perceptual and motor speed are general abilities, rests on faulty assumptions. The hypothesis was viewed as an over-generalization from Drake's original data. Some suggestions for future research were made.

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Appendix A

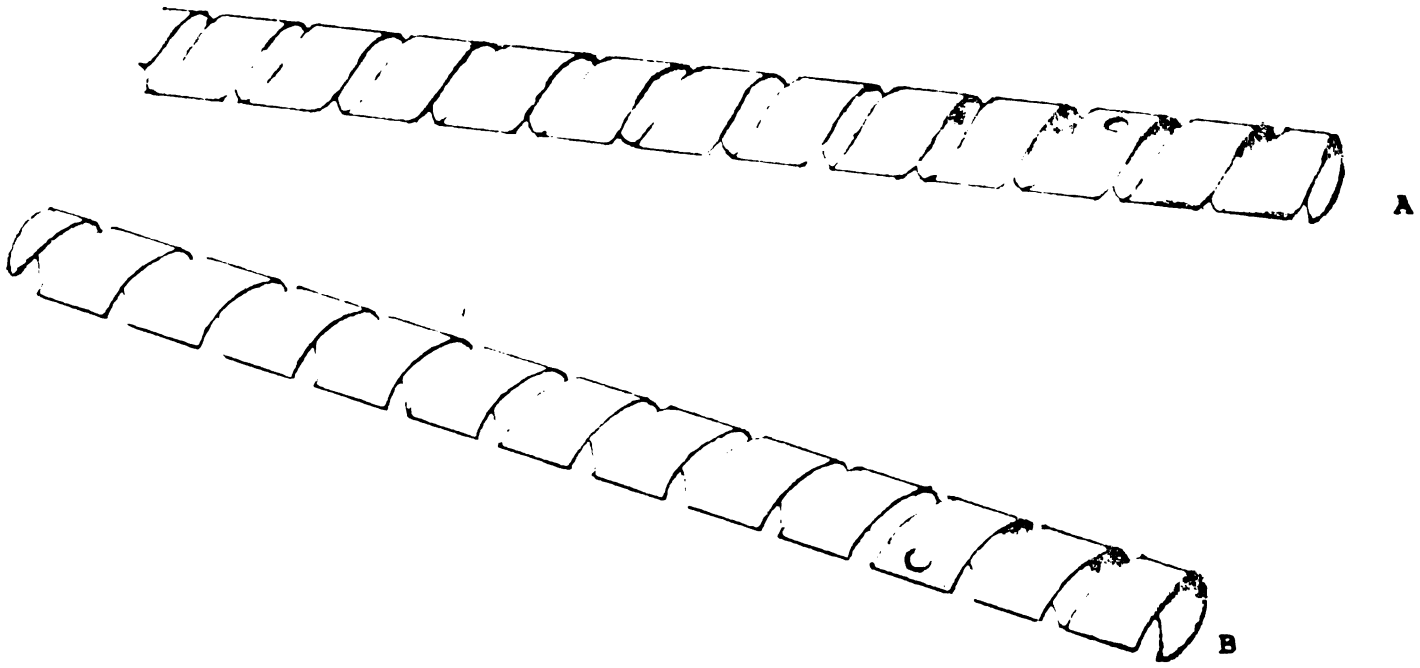
Perceptual and Motor Speed Tests

Spiral Inspection Test (P-SP)

Instructions

Here are some metal spirals. (Examiner shows five demonstration spirals.) Each of the spirals has a hole punched near one end. Some of the holes are punched "standard" and some "off-standard." Here is a standard spiral. (Examiner shows subject a standard spiral.) Standard means that the hole is punched 2½ turns from the end. A good way to identify a standard spiral is to hold the tip down and away from you. Then, if the spiral is standard, you will see that the hole is directly in line with the tip and on the third band. (Examiner demonstrates this procedure.) Here is an off-standard spiral. (Examiner shows an off-standard spiral.) You will notice that the hole is not punched 2½ turns from the end. Therefore, this spiral is off-standard. (Examiner continues the illustrations with the remaining demonstration spirals.) Here are some more spirals. (Examiner points to the large compartment in the spiral kit.) Now, I want to see how fast you can sort them into two piles. Put the standard spirals here and the off-standard spirals here. (Examiner indicates two labeled compartments in the kit.) Are there any questions? Now, when I say "begin", sort the spirals as fast as you can. Ready, begin!

(After subject completes task.) Good. Now, most people can sort the spirals in less time on the second trial. I'm sure you can do it faster. Let's try it again. Ready, begin!



DIAGRAMS OF THE SPIRALS FOR THE SPIRAL INSPECTION TEST. A, STANDARD;

B, OFF-STANDARD

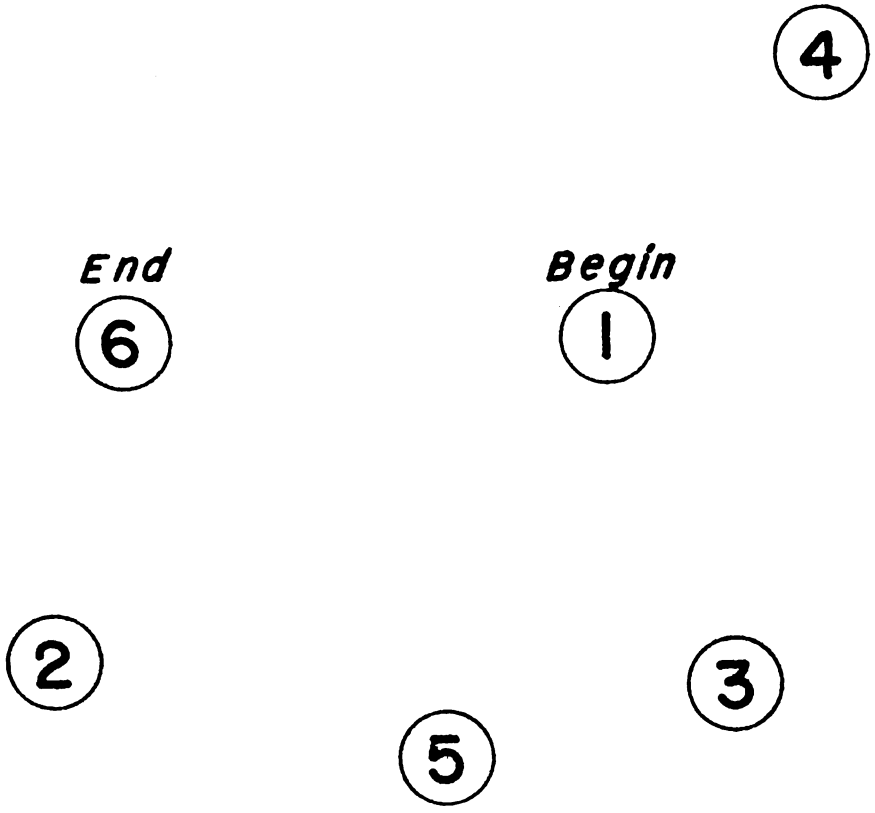
Perceptual Scanning Test (P-PS)

Instructions

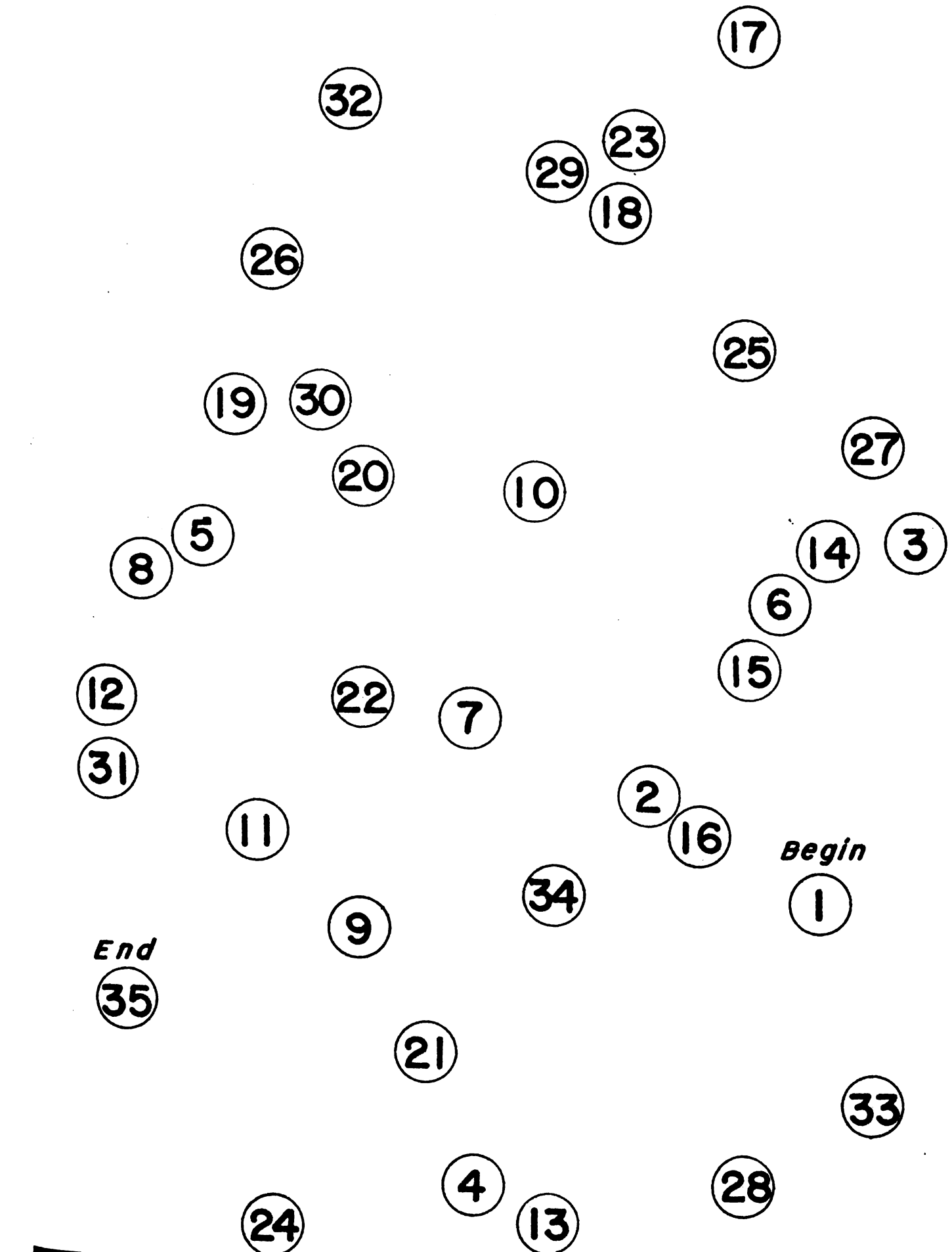
Here is a sheet of paper which has numbers scattered on it. (Examiner displays Practice Sheet.) The task is to find the numbers in order, beginning with number "1." Now, here is "1" on the Practice Sheet. (Examiner taps it with pencil.) You indicate that you've found each number by tapping it with the eraser-end of this pencil. Now, you tap the rest of the numbers on this sheet in order. (After subject finishes, examiner takes back pencil.) Are there any questions? Here is another sheet of paper with numbers on it. (Examiner produces Form A.) Beginning with "1," I want you to tap all the numbers in order as fast as you can. Remember, speed counts. (Examiner returns pencil to subject.) Are you ready? All right, begin!

(After subject completes task.) Fine. You've got the idea. However, I'm sure you can do even better. Let's see how fast you can really do it. Here's some more numbers. (Examiner produces Form B.) Ready, begin!

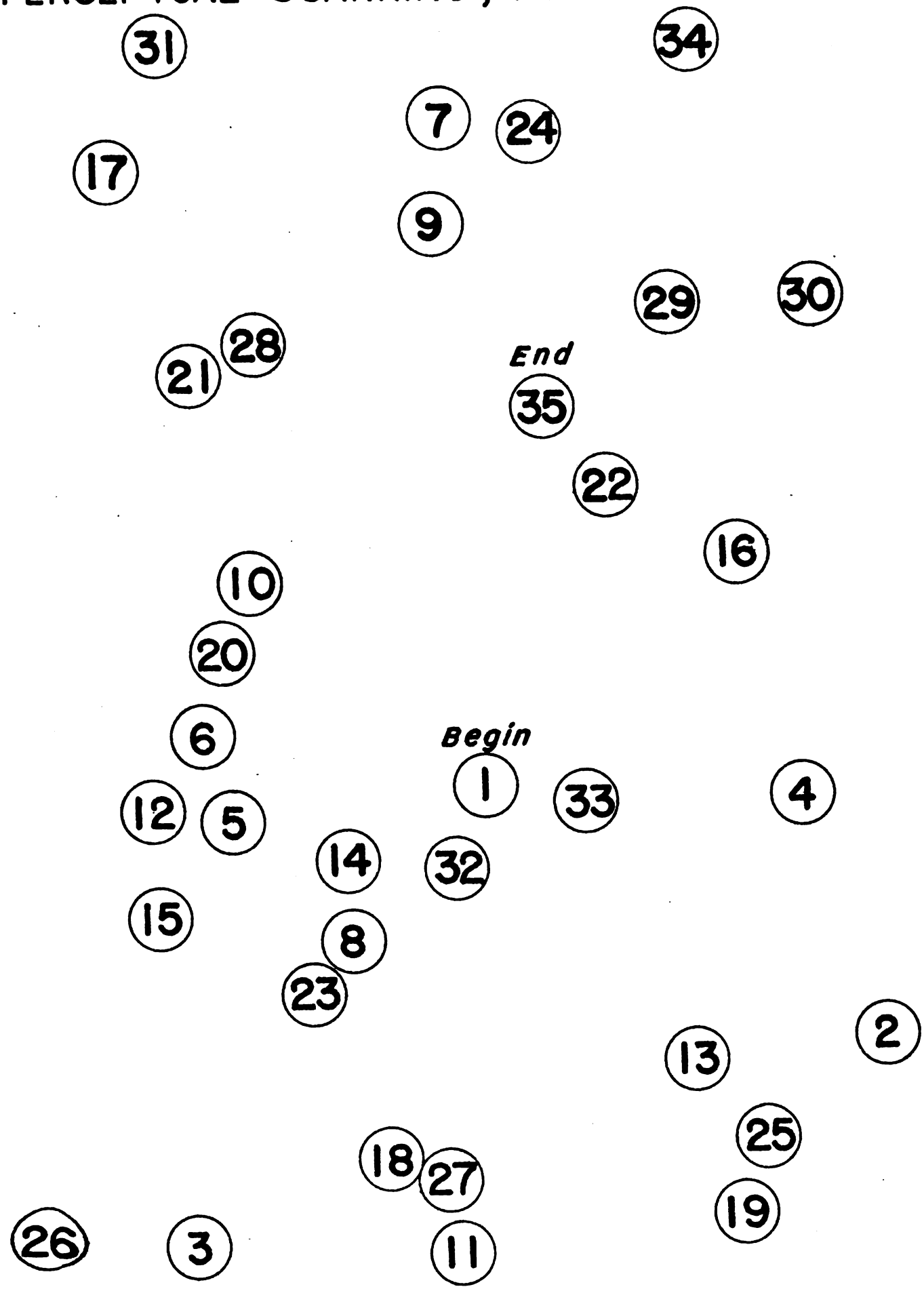
PERCEPTUAL SCANNING, PRACTICE SHEET



PERCEPTUAL SCANNING, FORM A



PERCEPTUAL SCANNING, FORM B



Number Recognition Test (P-NR)

Instructions

Here is a paper with numbers on it. (Examiner uses Practice Sheet.) The task is to look at each pair and decide whether the two numbers are the same or different. The numbers have to be exactly the same. Consider the numbers to be different if they're different in any way. Now, the first two numbers on this sheet are the same, so we underline the "S" for same. (Examiner demonstrates.) The next two are different, so we underline the "D" for different. (Examiner demonstrates.) You finish the rest of the pairs for practice. (After subject finishes the practice items.) Are there any questions? Here are some more pairs of numbers. (Examiner produces Form A) Let's see how fast you can mark them "S" or "D". Be accurate, but speed counts. I'm going to time you. Ready, begin!

(After subject completes task.) Good. Now that you've warmed up, I'm sure you can do it even faster. Most people can. Let's try it with this new set of pairs. (Examiner produces Form B.) Ready, begin!

NUMBER RECOGNITION, PRACTICE SHEET

22.91	22.91	S	D
44483	44438	S	D
$100.00	100.00	S	D
33.33	333.3	S	D
63.36%	63.36%	S	D

NUMBER RECOGNITION, FORM A

50	50	S	D	1/7.65	1/76.5	S	D
48	84	S	D	17170	17170	S	D
67.33	67.33	S	D	16(57	16)57	S	D
968?6	96?86	S	D	105%3	10583	S	D
10000.0	10000.0	S	D	855556	855556	S	D
85%	85%	S	D	(.01070)	(.01070)	S	D
2.532	2.532	S	D	-1246	-1246	S	D
3487942	3467942	S	D	8020802	8020802	S	D
=7583	=7583	S	D	38383838	38383383	S	D
0199#	0199;#	S	D	36,3636	36,3636	S	D
55538%	55538&	S	D	$50.19	$50,19	S	D
7,113	71,13	S	D	2372#	2372#	S	D
22262½	22262½	S	D	336-74	336-74	S	D
6475.5	6475,5	S	D	240@1	240%1	S	D
545-	545-	S	D	9292939	9292929	S	D
$600.69	$600.69	S	D	37.37	37.37	S	D
1237¾	1327¾	S	D	3029¾	3029¼	S	D
11/33	11/33	S	D	#49349	#49349	S	D
4786	4768	S	D	-28222-	-28222-	S	D
.0000007	.000007	S	D	54755	54.755	S	D
6111114	6111114	S	D	90/69	90169	S	D
3765½	3765¼	S	D	02:878	02;878	S	D
348*	348*	S	D	9060906	9060906	S	D
95045	95055	S	D	1565$5	156$55	S	D
7910!	79101	S	D	57.18%	57.18%	S	D

NUMBER RECOGNITION, FORM B

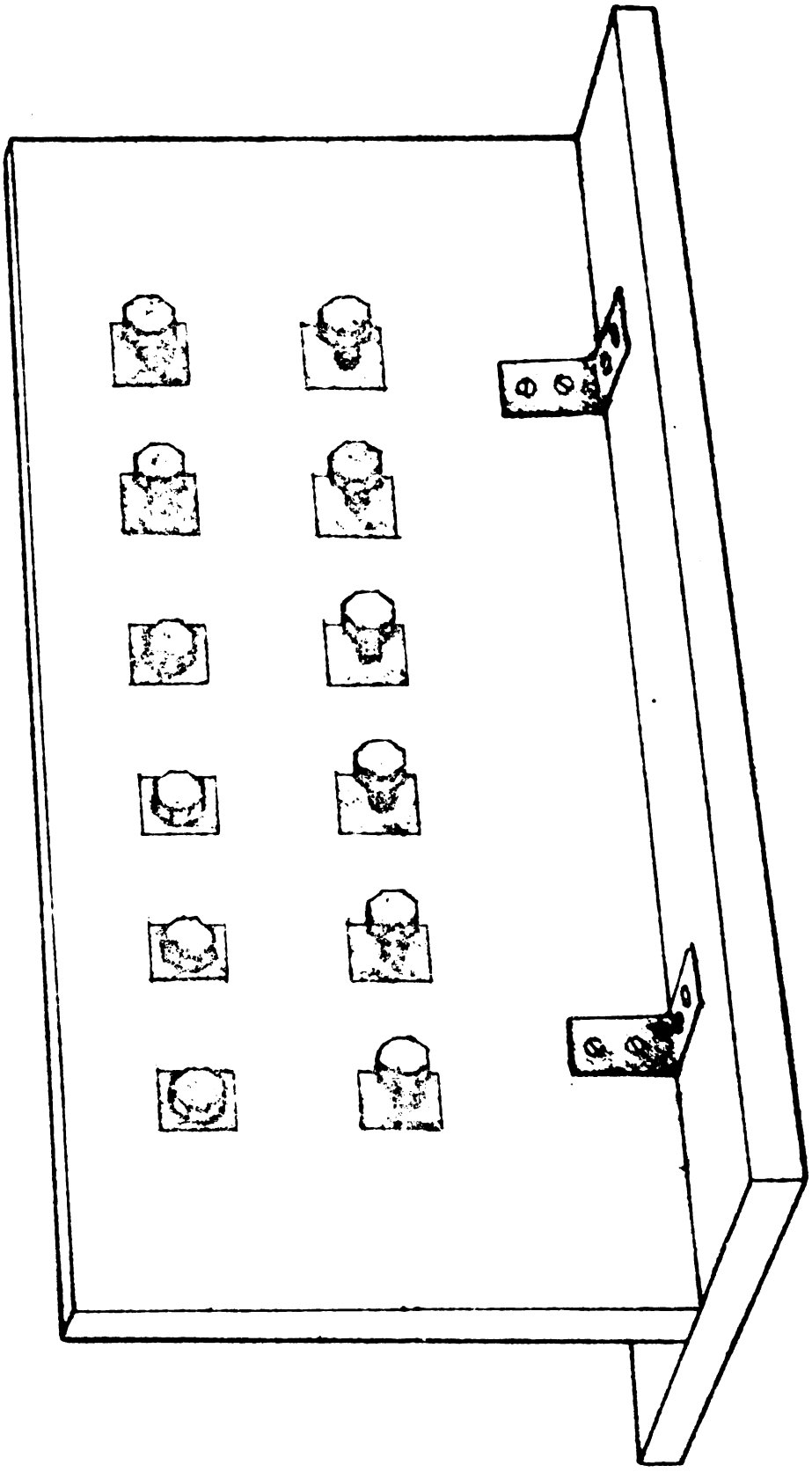
01/376	10/376	S	D	6201*	6201*	S	D
#4064'	#4064'	S	D	8243	8324	S	D
1437	1437	S	D	4848'	4848'	S	D
41010	41010	S	D	44/96	44/99	S	D
126412	124612	S	D	8&771	87&71	S	D
51/73.	51/.73	S	D	7558,7	7558.7	S	D
234423	234423	S	D	8178?	8178?	S	D
4829	4839	S	D	86.23¢	86.23¢	S	D
444446	444446	S	D	58745	58745	S	D
3574½	3574½	S	D	7130'	7130	S	D
002#21#	002#21	S	D	=5667	=5667	S	D
8528	8528	S	D	21.998	21,998	S	D
90966	99066	S	D	0505014	0505104	S	D
$66.22	$66.22	S	D	986%	986%	S	D
62069%	6206.9%	S	D	#35161	#35161	S	D
20 6/28	20 6/28	S	D	04/32.4	04/32.4	S	D
66666668	6666668	S	D	8007'	8007"	S	D
39323	39232	S	D	89578	89578	S	D
(606)2	(606)2	S	D	122?73	1227?3	S	D
+4827	+4827	S	D	$4.28	$4.29	S	D
796/655	796/656	S	D	34+87	34+88	S	D
659¢1	65¢91	S	D	503745	503745	S	D
3812	3821	S	D	-3443	+3443	S	D
17.69	17.69	S	D	259&2	259&2	S	D
66611¾	66111¾	S	D	667/752	667/762	S	D

Right Right Turning Test (M-RR)

Instructions

Here is a panel with some bolts in it. You will notice that the bolts aren't screwed into the panel. The task is to turn the bolts into the panel two at a time, one with your left hand and one with your right. You work with pairs of bolts and with both hands. (Examiner demonstrates.) Don't start on other bolts until you've finished both of the bolts that you're working on. The procedure is to begin with these bolts (point to upper left-hand corner) and go across the top row. (Examiner demonstrates.) When you finish the top row, you do the bottom row the same way, starting with these bolts (point to lower left-hand corner). Don't try to screw the bolts in tight. Stop when the bolts just touch the panel. Speed is important. Don't waste any time. Are there any questions? Now remember, you start right here (point to upper left-hand corner) and turn all the bolts into the panel as fast as you can. Don't forget, two at a time. Ready, begin!

(After subject completes task.) Good. Now, practically everybody does it faster the second time. Let's see how much faster you can do it the second time. Ready, begin.



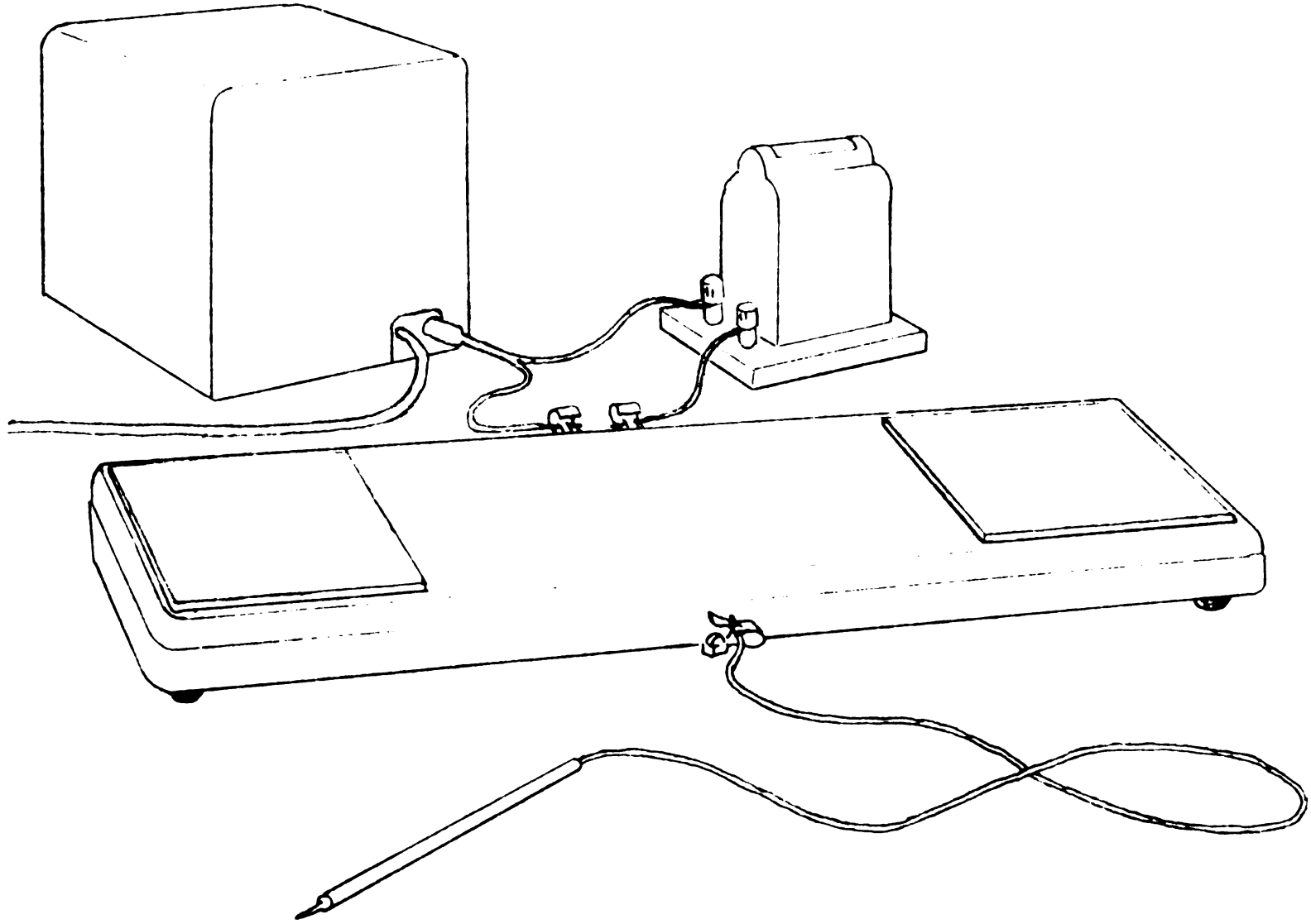
APPARATUS FOR THE RIGHT-LEFT TUMBLING TEST

Two Plate Tapping Test (M-TT)

Instructions

Here is a board with two metal plates, one at each end. The task is to tap first one plate and then the other with this pointer. You rotate it back and forth as rapidly as you can. (Examiner demonstrates.) Try it with your preferred hand. Are you right-handed or left-handed? (Examiner hands pointer to subject.) You can practice for a few seconds. (After about 10 sec. of practice.) Now, let's see how quickly you can make 100 taps. When I say, "begin," start tapping as fast as you can until I say, "stop." Are there any questions? Ready, begin.

(After subject completes task.) Good. Now, let's see how fast you can do it with your other hand. Ready, begin!



APPARATUS FOR THE TWO-PLATE TAPPING TEST

Minnesota Rate of Manipulation Test (M-RM)

Instructions

Here is a board filled with blocks. (Examiner arranges board in correct position.) This is the starting position. The object is to see how fast you can turn the blocks over. You do it like this - . (Examiner demonstrates as he talks.) With your left hand, lift the block from the upper right-hand hole, and with your right hand put it back, bottom side up, into the same hole. (Examiner continues turning blocks across the board as he talks.) Work to the left across the board, picking up the blocks with your left hand and putting them down with your right, bottom side up. (After examiner finishes first row.) As you work back to the right in the next row, you pick them up with your right hand and put them down with your left. Examiner continues turning blocks about half way across the row, then turns all blocks to the original position.) Always pick up the blocks with the hand that leads and put them down with the hand that follows. Before you finish be sure that every block is all the way down. Are there any questions? Your score will be the number of seconds it takes you to do this, so work as fast as you can. Put your hand on the first block. Ready, begin!

(After subject completes task.) Good. But remember I'm timing you. Let's do it even faster this second time. Put your hand on the first block. Ready, begin!

Appendix B

Intercorrelations Among Personal, Perceptual, and Motor Variables (Table A-1)

Table A-1[a]

	P-SI	P-PS	P-NR	M-RT	M-TT	M-RM	Age	Educ.	Vocab.	Wkly. Miles	Accid.
P-PS	≠.46										
P-NR	≠.52	≠.69									
M-RT	≠.40	≠.28	≠.23								
M-TT	≠.34	≠.33	≠.37	≠.46							
M-RM	≠.49	≠.44	≠.39	≠.52	≠.45						
Age	≠.45	≠.39	≠.35	≠.44	≠.18	≠.39					
Educ.	-.35	-.50	-.54	-.18	-.35	-.20	-.12				
Vocab.	-.27	-.39	-.41	≠.02	-.20	-.13	≠.04	≠.61			
Wkly. Miles	≠.05	≠.10	≠.10	-.11	-.06	-.08	-.05	-.10	-.14		
Accid.	-.06	-.01	≠.04	≠.13	≠.04	-.03	-.25	-.52	-.12	-.08	
Yrs. Driven	≠.40	≠.31	≠.27	≠.38	≠.14	≠.32	≠.94	-.12	≠.11	≠.03	-.22

[a] $\underline{r}$ = .14, $\underline{p}$<.05.
$\underline{r}$ = .19, $\underline{p}$<.01.
$\underline{N}$ = 199.

Appendix C

Age Distributions of the Research Groups and Michigan Drivers: A Comparison (Table A-2)

Table A-2

Age	Both Research Groups[a] Obtained Frequency	%	Michigan Male Drivers[b] Expected Frequency	%
75 +	0	0	1.2	1.7
70-74	1	1.4	2.0	2.9
65-69	1	1.4	3.3	4.7
60-64	5	7.1	3.9	5.6
55-59	4	5.7	5.0	7.1
50-54	4	5.7	6.3	9.0
45-49	8	11.4	6.5	9.3
40-44	9	12.9	7.6	10.8
35-39	9	12.9	8.0	11.4
30-34	10	14.3	8.5	12.1
25-29	9	12.9	7.5	10.7
20-24	7	10.0	6.4	9.1
15-19	3	4.3	4.0	5.7
Total	70.2	100.1	70.0	100.0

[a]The problem-driver and control groups have the same age distribution.

[b]Based on normative data from King (1959).

Appendix D

Factor Analysis of the Perceptual and Motor Speed Tests (Table A-3)

Table A-3[a]

	Principal Axis Loadings		Rotated Loadings	
Tests	I	II	I	II
P-SI	.703	.041	.404	.577
P-PS	.728	.384	.150	.810
P-NR	.730	.440	.107	.846
M-RT	.598	-.472	.741	.177
M-TT	.614	-.272	.594	.313
M-RM	.719	-.251	.643	.409

[a] $\underline{N}$ = 199

Appendix E

Comparison of the Problem-Driver and Control Groups on Number of Errors Incurred on P-SI and P-NR (Table A-4)

Table A-4

Tests	Groups[a] Problem-Driver M	Problem-Driver SD	Control M	Control SD
P-SI	5.44	7.40	7.07	7.95
P-NR	4.43	4.66	4.01	4.35

[a]None of the differences are statistically significant.

Appendix F

Comparison of the Problem-Driver and Control Groups on Perceptual-Motor Speed Discrepancies (*t* and *F* ratios) (Table A-5)

Table A-5

Test Pairs	Groups: Problem-Driver M	Problem-Driver SD	Control M	Control SD	t	F
P-SI vs. M-RT	-.025[a]	.933	.025	1.255	.27	1.81[c]
vs. M-TT	.084	.994	-.084	1.138	.93	1.31
vs. M-RM	-.106	.903	.106	.946	1.35	1.08
P-PS vs. M-RT	.074	1.115	-.074	1.322	.71	1.41
vs. M-TT	.182	1.161	-.182	1.246	1.79[b]	1.35
vs. M-RM	-.007	1.247	.007	.777	.08	2.58[d]
P-NR vs. M-RT	.014	1.200	-.014	1.260	.13	1.10
vs. M-TT	.122	1.069	-.122	1.169	1.29	1.20
vs. M-RM	-.067	1.310	.067	.845	.72	2.40[d]

[a]High scores mean relatively faster motor speed than perceptual speed.

[b]$p < .10$

[c]$p < .02$

[d]$p < .01$