Development of a Taxonomy of Human Performance:

Validation Study of Ability Scales for Classifying Human Tasks

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13. ABSTRACT

This report is the second of a series of studies designed to explore the feasibility of an approach to the development of a comprehensive taxonomy of tasks based upon the use of known parameters of human performance for describing and classifying tasks. The first report described the development of human abilities based rating scales and presented data on their reliability. The present report focuses on establishing preliminary estimates of the construct and predictive validity of these scales. The validity data were obtained through judges' ratings of a set of 38 tasks on 37 ability rating scales. The results of this research indicated that judges' rating of tasks on human ability dimensions bear a substantial degree of relationship to the empirically derived factor loadings for those same tasks on factors analogous to the ability scales. In addition, the results demonstrated that ratings of tasks on ability scales can be used to predict human task performance. A multiple correlation coefficient of 0.64 was associated with this latter finding. Coupled with the results of the first study in this series, these results indicate that an approach to the development of a task taxonomy based human ability rating scales can serve to reliably and validly describe, classify and predict human performance on a variety of tasks.

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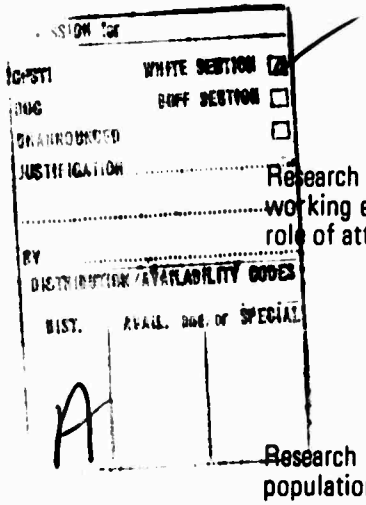

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DEVELOPMENT OF A TAXONOMY OF HUMAN PERFORMANCE:

VALIDATION STUDY OF ABILITY SCALES FOR CLASSIFYING HUMAN TASKS

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Edwin A. Fleishman

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PREFACE

The AIR Taxonomy Project was initiated as a basic research effort in September 1967, under a contract with the Advanced Research Projects Agency, in response to long-range and pervasive problems in a variety of research and applied areas. The effort to develop ways of describing and classifying tasks which would improve predictions about factors affecting human performance in such tasks represents one of the few attempts to find ways to bridge the gap between research on human performance and the applications of this research to the real world of personnel and human decisions.

The present report is one of a series which resulted from work undertaken during the first three years of project activity. In 1970, monitorship of the project was transferred from the Air Force Office of Scientific Research (AFOSR) to the U. S. Army Behavior and Systems Research Laboratory (BESRL), under a new contract. This report, completed under the new contract, is among several describing the previous developmental work. It is also being distributed separately as a BESRL Research Study.

EDWIN A. FLEISHMAN
Senior Vice President and
Director, Washington Office
American Institutes for Research

FOREWORD

The American Institutes for Research is engaged in a research program to develop and evaluate systems for describing and classifying tasks which can improve generalization of research results about human performance and to develop a common language for communicating between researchers and individuals who need to apply research to personnel selection, training, and equipment design problems.

This program is concerned with new ways of describing tasks and duties. The objective is to develop theoretically-based language systems (taxonomies) which, when merged with appropriate sets of decision logic and appropriate sets of quantitative data, can be used to make predictions about human performance. Such taxonomies should be useful, for example, when future management information and decision systems are designed for personnel use. Under the project several different taxonomic systems have been developed, each of which seemed to have maximum relevance for a different type of application. These include the ability-requirement approach; the task characteristics approach; an approach based on information theory; and a "criterion measures" approach.

The present publication reports on an effort to derive preliminary estimates of the construct and predictive validity of the human abilities approach. Task rating scales, based on this approach, were developed to provide a performance-oriented task classification system and a language for describing tasks in terms of their human ability requirements. In the present study ratings by observers using such scales were found predictive of actual performance levels as well as of empirical estimates of the abilities required by these tasks.

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DEVELOPMENT OF A TAXONOMY OF HUMAN PERFORMANCE: VALIDATION STUDY OF ABILITY SCALES FOR CLASSIFYING HUMAN TASKS

BRIEF

Requirement:

The development and evaluation of systems for describing and classifying tasks which can improve generalization of research results about human performance is essential for organizing, communicating, and implementing these research findings. The present report is the second of a series of studies designed to explore the development of one such system which is based upon the human ability requirements demanded by performance on various tasks. The first study presented the reliabilities of human ability based task rating scales. This report presents an effort to establish preliminary estimates of the construct and predictive validity of these scales.

Procedure:

A panel of nine judges was asked to rate each of 38 tasks in terms of an instrument called the Task Assessment Scales. These scales allowed each task to be rated on a set of thirty-five scales representing different human ability requirements. These data were subjected to two separate analyses. First, coefficients of correlation and similarity were used to examine the relationship between selected ability scales and empirically derived ability factors which they were designed to represent. This analysis provided an estimate of the construct validity of the scales. Second, the judges' ratings of the tasks on the ability scales were used to predict performance on those tasks. Mean performance data on the tasks were obtained from an earlier factor-analytic study utilizing these tasks. A multiple regression technique was used to determine the predictive relationship which existed between the ability ratings and performance on the tasks.

Findings:

In general, it was found that the ability scales possessed substantial construct and predictive validity. The task ratings on the eight scales which were assessed for construct validity were significantly correlated with the factor loadings for these same tasks on factors which corresponded to these scales. Further, a multiple regression equation was generated which indicated that a set of three ability scales were significantly related to ($R=.64$, $p < .01$) performance on the tasks which were rated.

Utilization of Findings:

Although a final interpretation of these findings must await subsequent cross-validation efforts, it does appear that the Task Assessment Scales validly describe human tasks. Coupled with the results of the first study in this series, the results indicate that an approach to the development of a taxonomy of human performance based upon human ability based rating scales can provide a reliable and valid means for describing, classifying, and predicting human performance on a variety of tasks.

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INTRODUCTION

For many years there has been a need in the behavioral sciences for a unifying system of dimensions for describing human task performance. This need has been documented by Melton and Briggs (1960), Fitts (1962), Fleishman (1962, 1967), and Miller (1962). The absence of a comprehensive taxonomic system limits the ability of behavioral scientists to compare research results from different studies and to generalize results to new settings. At present, research results obtained in one task can be related safely only to tasks which are so highly similar as to be almost identical. Further, the absence of a well-defined task descriptive language hampers the communication of research results. Those scientists who must apply research findings to operational problems are without a language for unambiguously reporting and interpreting research findings.

One approach to development of the needed taxonomic system for describing and classifying human tasks lies in the use of performance dimensions which have been identified and defined in factor analytic studies of the intercorrelations among task performances in a variety of performance areas. Most of the existing information on the categorization of human skills, which is based upon empirical relationships among actual task performances, is derived from such correlational studies. The result of this research has been the establishment of sets of abilities encompassing much of the cognitive, perceptual, psychomotor, and physical areas of performance. Since these ability dimensions can be considered to specify the "categories" of performance which may be required for performance on almost any type of task, they provide one natural basis for describing and classifying tasks in terms of human performance requirements.

The rationale for the "ability requirements" approach to the problem of developing a taxonomy of human performance has been detailed in earlier reports (Fleishman, 1967a; Fleishman, 1967b; Theologus, Romashko, & Fleishman, 1970). Briefly, the "ability requirements" approach described a task in terms of the human abilities required to perform it, such that an entire task could be described in terms of a profile of basic abilities which accounted for performance on the task. Performance would be expected to be highly similar between tasks which call for similar patterns of abilities. If tasks were evaluated in terms of required abilities, then performance on new tasks could be predicted from tasks with similar ability requirements and classified according to ability profiles.

PURPOSE

In order to assess the feasibility of the human abilities based approach to the development of a task taxonomy, a series of studies was planned. This report presents the second study in this series. An earlier report (Theologus, et al., 1970) described the development of a prototypical task rating instrument, the Task Assessment Scale (TAS), based on a set of human ability rating scales. Examples of these scales are shown in Appendix A and the complete TAS can be found in the report by Theologus, et al. (1970). Within this research effort two interrelated studies were conducted to determine the reliability with which the scales could be used in describing tasks in terms of their ability requirements. These studies also were used to suggest avenues for the refinement of the scales. The results of this research indicated that adequate reliability could be achieved with the preliminary form of the TAS. The intraclass correlation coefficients indicated that substantial reliability could be obtained when large panels of task raters ($n \tilde{=} 20$) were employed. For smaller panels of judges ($n = 5$) high reliability could be expected on over half of the scales. Further analysis of the data utilizing coefficients of similarity revealed that the judges in general agreed on the "profiles" of ability requirements for each of the tasks rated on the ability scales. These findings were quite encouraging with respect to the development of the TAS, and suggested that, with further refinement, the contruction of a highly reliable instrument is possible.

Before attempting to further enhance the reliability of the TAS, it was decided to obtain preliminary estimates of its validity. The present study was designed to evaluate validity in two different ways. First, we wished to estimate the construct validity of the scales; that is, the relationship between ability scale and empirically derived ability factors which they were designed to represent. Specifically, we sought to correlate the ratings of tasks on ability scales given by a panel of judges with the factor loadings

of these tasks on the same ability factors established in previous experimental-correlational research on the dimensionality of human performance. High construct validities would demonstrate that the ability scales did indeed reflect actual human ability categories. Second, the present research was designed to assess the predictive validity of the TAS scales. We needed to determine whether the ratings of a task on the TAS scales could be used to predict performance on that task. Substantial predictive validities would indicate the potential effectiveness of the TAS in such applications as assigning personnel to different military specialties, estimating performance in specialized tasks, and selecting personnel for admission to various military schools.

To accomplish both of these purposes within a single experiment and without gathering large amounts of performance data, we required a detailed report of an already existing factor-analytic study which met the following criteria. The report had to provide factor loadings on ability factors which corresponded to abilities represented by scales in the TAS. These loadings were necessary for the estimation of the construct validity of the scales. The report also had to present the mean performance levels of a group of subjects on each of the tasks which were factor analyzed. Additionally, the mean performance data had to be represented in a common metric or had to be convertible to a common metric. Such data were needed to serve as criterion measures in assessing the predictive validity of the ability scales. Finally, the tasks employed in the factor-analytic study had to be described in sufficient detail to permit accurate estimation of its ability requirements by judges in the present research. On these bases, a factor-analytic study of psychomotor performance was selected (Fleishman, 1954). This study had analyzed the intercorrelations among a set of 38 tasks administered to 400 subjects. Comprehensive descriptions of each of the tasks were available. This study also provided eight ability factors corresponding to scales in the TAS and a common measure of performance on 27 of the 38 tasks. Furthermore, the ability factors had been replicated in later factor-analytic research (Fleishman, 1964).

METHOD

To obtain the data necessary for the present research, a panel of nine judges was asked to rate descriptions of each of the 38 tasks from Fleishman's study on each of the scales in the TAS. The panel of judges employed in the study was comprised of male students from a local university. University students were utilized for two reasons. First, it is hoped that an ability-based task classification system would eventually be used by judges who might not be psychologists. University students selected without regard to academic discipline are fairly representative of this foreseen user population. Second, since university students had been used in the previous study of the reliability of the prototype TAS, for the sake of comparability, we wished to obtain validity data from the same population.

The task descriptions which the panel of judges rated on the ability scales were adapted from those presented by Fleishman (1954). To enhance the clarity of the original task descriptions, each of the descriptions was carefully reviewed. As a result of this review some minor editorial modifications were made and, in those cases where it was felt to be beneficial, the experimenter's instructions to the subjects were included in the task descriptions. The descriptions, as they were utilized in the present research, are presented in Appendix B.

In rating each of the 38 task descriptions on each of the 37 ability scales in the TAS, the judges were asked to follow a two stage rating procedure. First, they had to decide whether an ability was required for performance on the task. If their decision was "no" (a rating of zero), they would proceed to the next ability scale. If their decision was "yes," they would rate the task on a seven-point scale. In making these ratings, the judges were asked to estimate the lowest amount of an ability which a subject could possess and still produce errorless performance on the task. A copy of the actual instructions which was presented to each of the judges is shown in Appendix B.

ANALYSIS AND RESULTS

The data obtained during this study were analyzed in two ways. First, they were analyzed to determine the degree of relationship between the factor loadings of the tasks on the factors identified in the study by Fleishman (1954) and the judges' ratings of the tasks on the ability scales which corresponded to these factors. The second analysis was intended to determine whether the judges' ratings of a task on the ability scales were correlates of performance on that task using the data from the earlier Fleishman study as criteria.

Construct Validity

The first step in estimating the degree of relationship between the factor loading for the tasks and the judges' ratings of them, involved an examination of the definitions of the factors in Fleishman's study in order to determine which of the factors corresponded to the rating scales employed in the present study. Of the twelve factors identified by Fleishman, eight were found to be comparable in definition to scales in the TAS. These eight factors and the associated scales are shown in Table 1.

To assess the relationship between the ratings and factors, coefficients of correlation and of similarity (Cattell, Coulter, and Tsujioka, 1966) were employed. In estimating the degree of similarity between two distributions, comparisons can be made on any or all of three parameters of the distributions: level, dispersion, and shape. Since the correlation coefficient operates on standard scores (z scores), it equates the distributions on level and dispersion and compares them only in terms of shape. In the present analysis, there is justification for equating the distributions of ratings and factor loadings for level and dispersion since the values for these parameters are a function of the scales

Table 1

FACTOR LOADINGS ON THE EIGHT FACTORS*
(Taken from Fleishman, 1954)

Tasks	Factor Number**							
	1	2	3	4	5	6	7	8
1. Precision Steadiness	25	-02	11	-02	01	03	50	07
2. Steadiness Aiming	02	-05	06	06	07	03	60	07
3. Track Tracing	15	12	21	19	21	-05	61	16
4. Two Plate Tapping	21	12	54	36	02	24	05	12
5. Key Tapping	28	15	19	23	03	24	06	12
6. Ten Target Aiming	00	07	66	06	15	05	02	15
7. Rotary Aiming	-02	15	46	36	18	20	04	-03
8. Hand Precision Aiming	01	04	14	27	03	16	09	-14
9. Visual Reaction Time	05	73	19	11	12	02	-02	09
10. Auditory Reaction Time	00	68	05	10	04	11	-03	02
11. Minnesota (placing)	14	22	36	22	31	32	12	-06
12. Minnesota (turning)	15	17	21	20	34	38	09	21
13. Purdue (right hand)	10	25	22	11	46	19	14	-09
14. Purdue (left hand)	08	02	13	19	58	13	06	08
15. Purdue (both hands)	02	19	14	10	61	21	09	10
16. Purdue (assembly)	07	15	03	17	55	21	08	18
17. O'Connor	18	13	19	13	53	25	10	10
18. Santa Ana	-01	-09	09	26	16	47	05	15
19. Punch Board	20	22	29	25	15	21	30	00
20. Pin Stick	07	-03	25	23	19	28	16	20
21. Dynamic Balance	03	10	13	-01	05	-08	03	35
22. Postural Discrimination (vertical)	18	03	03	10	07	02	-01	08
23. Postural Discrimination (angular)	12	00	11	-01	-02	03	00	05
24. Rotary Pursuit	04	10	22	21	04	17	16	53
25. Discrimination Reaction Time	53	02	05	16	21	10	00	28
26. Complex Coordination	51	05	09	12	23	-01	19	36
27. Rudder Control	20	02	-03	16	-11	-01	14	45
28. Medium Tapping	01	11	22	74	10	18	13	08
29. Large Tapping	06	09	21	74	10	11	12	05
30. Aiming	-02	08	28	45	12	13	01	04
31. Pursuit Aiming I	02	09	16	50	14	18	00	-01
32. Pursuit Aiming II	03	05	08	48	18	06	02	07
33. Square Marking	12	19	07	29	12	-05	07	11
34. Tracing	17	07	21	28	14	-15	15	04
35. Steadiness	10	22	10	07	-01	10	31	02
36. Discrimination Reaction Time (printed)	42	-02	07	14	04	26	13	15
37. Marking Accuracy	26	03	15	29	20	01	02	-01
38. Log Book Accuracy	29	03	12	23	08	28	00	-01

*Decimal point is eliminated.

**Refers to factor numbers shown with associated names in Table 3.

which underlie them. Thus, the analysis in terms of the correlations should be viewed as the primary analysis.

The analysis using the coefficient of similarity (r_p) provided supporting data.* This coefficient compares the distributions under consideration on all three parameters. It, therefore, reflects differences in level and dispersion which are more related to the scale employed rather than to rating accuracy.

In order to calculate these two statistics, the factor loadings for the thirty-eight tasks on the eight factors were transformed via Fisher's z (Hays, 1965, p. 530) to normalize their distributions. The means of ratings by the judges on the corresponding ability scales were calculated for each task. The factor loadings are presented in Table 1 and the mean ratings are shown in Table 2.

The correlation and similarity coefficients from this analysis are presented in Table 3. These data demonstrate a substantial amount of agreement between the factor loadings and the mean ratings in all cases except the comparison of Speed of Limb Movement (Scale No. 29), and Rate of Arm Movement (Factor No. 3). An examination of the definitions for this scale and factor indicated that Speed of Limb Movement scale was more generic than the factor, Rate of Arm Movement. It encompasses both arm and leg movements while the associated factor is restricted to arm movements only. Therefore, we hypothesized that, if all tasks which included leg movements were eliminated from the analysis, higher

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$$*r_p = \frac{E_k - \sum_{i=1}^{k} d_i^2}{E_k + \sum_{i=1}^{k} d_i^2}$$

Where:

k = The number of dimensions in the comparison.

E_k = Twice the median chi-square value for k degrees of freedom

d = The difference, in standard score units, between the distributions on each successive element.

Table 2

MEAN RATINGS ON EIGHT ABILITY SCALES

Tasks	Ability Scale Number*							
	27	28	29	30	33	34	35	37
1. Precision Steadiness	.33	1.00	.67	.78	.56	1.89	4.11	1.56
2. Steadiness Aiming	.78	1.11	.56	1.11	.44	2.22	4.44	1.56
3. Track Tracing	.67	1.11	.56	.89	.67	2.00	3.67	1.22
4. Two Plate Tapping*	.89	2.33	2.11	3.44	.89	1.56	.56	.89
5. Key Tapping*	1.00	2.00	1.89	3.89	1.67	1.11	.22	.33
6. Ten Target Aiming*	.56	1.78	1.33	2.22	.56	1.44	2.44	.89
7. Rotary Aiming*	.56	2.00	1.33	2.89	1.56	1.22	1.33	.56
8. Hand Precision Aiming*	.67	2.00	1.33	2.89	1.22	1.78	2.44	1.00
9. Visual Reaction Time*	1.56	3.00	1.44	3.11	.56	.78	.44	.67
10. Auditory Reaction Time*	1.44	2.89	1.33	3.33	.44	.78	.33	.67
11. Minnesota (placing)*	1.11	2.11	.89	2.89	2.56	2.44	1.44	.67
12. Minnesota (turning)*	1.22	2.11	1.33	3.00	2.22	3.11	1.44	1.00
13. Purdue (right hand)*	.78	2.11	1.00	3.00	2.44	2.11	1.67	.78
14. Purdue (left hand)*	1.00	2.11	1.33	3.11	2.44	2.11	1.89	1.11
15. Purdue (both hands)*	.78	2.22	1.44	3.11	2.44	2.44	1.56	.56
16. Purdue (assembly)*	1.56	2.11	1.44	3.11	3.22	2.56	1.78	.89
17. O'Connor*	1.00	2.33	1.00	3.00	3.33	2.67	1.44	.89
18. Santa Ana*	.56	2.22	1.00	2.78	3.00	2.44	1.56	.89
19. Punch Board*	1.11	2.33	1.11	3.22	2.11	2.00	1.89	.78
20. Pin Stick*	1.00	2.00	1.00	3.22	2.22	2.33	2.44	1.11
21. Dynamic Balance*	1.11	1.89	1.00	.33	.44	.00	.33	1.89
22. Postural Discrimination (vertical)	1.33	1.11	1.11	1.00	.56	.33	.22	3.11
23. Postural Discrimination (angular)	1.22	.78	1.11	1.00	.67	.11	.22	3.11
24. Rotary Pursuit	.78	2.00	1.11	2.33	.67	2.56	3.22	3.33
25. Discrimination Reaction Time	2.89	2.56	1.33	2.89	1.00	.78	.56	1.22

Table 2. Mean Ratings on Eight Ability Scales (Continued)

Tasks	Ability Scale Number							
	27	28	29	30	33	34	35	37
26. Complex Coordination	2.44	1.56	1.67	1.44	.11	.00	.44	2.44
27. Rudder Control	2.44	2.11	2.00	1.22	.22	.22	1.11	2.67
28. Medium Tapping*	1.22	1.78	1.33	2.89	1.22	1.78	1.00	.78
29. Large Tapping *	.89	1.89	1.00	2.78	1.22	1.67	1.00	.56
30. Aiming*	1.11	1.67	1.22	2.89	1.44	1.44	2.00	.78
31. Pursuit Aiming I*	.67	1.44	1.00	2.67	1.67	1.56	1.44	.33
32. Pursuit Aiming II*	.89	1.44	1.00	2.67	1.44	1.56	1.33	.33
33. Square Marking*	.56	1.89	.89	1.76	1.11	1.22	1.22	.68
34. Tracing*	.89	1.22	.67	1.64	1.11	1.89	1.89	.67
35. Steadiness	.33	.78	.56	1.00	1.33	1.56	2.89	1.07
36. Discrimination Reaction Time (printed)*	1.67	1.67	.33	1.23	.89	1.11	.44	.67
37. Marking Accuracy*	1.11	1.78	.67	1.89	.89	1.56	1.00	.31
38. Log Book Accuracy	1.00	1.33	.22	1.63	.78	1.56	1.11	.42

*Refers to ability scale numbers shown with associated names in Table 3.

Table 3

CORRELATION AND SIMILARITY COEFFICIENTS
BETWEEN MEAN ABILITY RATINGS AND TRANSFORMED FACTOR LOADINGS

Scale No.	Ability Scale Name	Factor No.	Factor Name (Fleishman, 1954)	r_{xy}	r_p
27.	Choice Reaction Time	1.	Spatial Relations***	.40*	.24*
28.	Reaction Time	2.	Reaction Time	.74**	.58**
29.	Speed of Limb Movement	3.	Rate of Arm Movement	.22	.11
30.	Wrist-Finger Speed	4.	Wrist-Finger Speed	.77**	.63**
33.	Finger Dexterity	5.	Finger Dexterity	.55**	.37**
34.	Manual Dexterity	6.	Manual Dexterity	.56**	.38**
35.	Arm-Hand Steadiness	7.	Arm-Hand Steadiness	.61**	.43**
37.	Control Precision	8.	Psychomotor Coordination***	.62**	.45**

*Significant at $p < .05$
**Significant at $p < .01$
***In later research on basic human abilities Spatial Relations was renamed Response Orientation, the factor which Scale No. 27 was designed to measure. The factor of Psychomotor Coordination has been divided into two factors, Multilimb Coordination and Control Precision, as a result of further insight into its nature.

coefficients of correlation and similarity would be obtained. Three such tasks were present in the analysis: Dynamic Balance, Complex Coordination, and Rudder Control. With these tasks removed, the coefficient increased to 0.36 ($p < .05$), and the similarity coefficient increased to 0.21 (p = n.s.). Thus, it can be safely concluded that the mean ratings on all of the ability scales were found to be significantly related to the factor loadings on the corresponding factors, although there were differences in degree of agreement depending on the ability category. Essentially, both predictions of factor loadings from independent ratings of task ability requirements of these 38 tasks were obtained for Reaction Time, Wrist-Finger Speed, Control Precision, and Arm-Hand Steadiness.

Tables 4 through 11 elucidate the nature of the relationships expressed in the correlations between the factor loadings and the mean ratings for each ability. These tables present those tasks having factor loadings greater than or equal to 0.30 and those with mean ratings greater than or equal to 2.00 within each ability factor. Also presented is the relative rank of the factor loading and rating for each of the tasks. These tables indicate more clearly, the nature of the agreement (or disagreement) between empirically derived factor loadings and ability ratings of the tasks made by independent observers. Thus, for the 38 tasks, three had factor loadings above .40 on Choice Reaction Time and these same three tasks were all ranked in the top four on this factor by the independent ratings of the observers (Table 4). The next table, Table 5, indicates that the two task loadings on the Reaction Time factor did receive the two top ranks by the observers on the Reaction Time rating scale. Of the tests loaded on the Finger Dexterity factor (Table 8), seven tasks received loadings above .30 and, it can be seen, all of these received independent ratings from 1 to 8. Table 9 shows that with Manual Dexterity, three tests received loadings above .30 and two of these were among the top three in the observer ratings (Table 9). Table 9 summarizes the results

Table 4

COMPARISON OF TASKS WITH HIGH FACTOR LOADINGS ON FACTOR 1 (SPATIAL RELATIONS) AND HIGH MEAN RATINGS ON SCALE 27 (CHOICE REACTION TIME)

	Factor Loading		Rating	
	Value	Rank	Value	Rank
Tasks with factor loadings $\geq$ .30				
25. Discrimination Reaction Time	.53	1	2.89	1
26. Complex Coordination	.51	2	2.44	2.5
36. Discrimination Reaction Time (Printed)	.42	3	1.67	4
Tasks with ratings $\geq$ 2.00				
27. Rudder Control	.20	9.5	2.44	2.5

Table 5

COMPARISON OF TASKS WITH HIGH FACTOR LOADINGS ON FACTOR 2 (REACTION TIME) AND HIGH MEAN RATINGS ON SCALE 28 (REACTION TIME)

	Factor Loading		Rating	
	Value	Rank	Value	Rank
Tasks with Factor Loadings ≥ .30				
9. Visual Reaction Time	.73	1	3.00	1
10. Auditory Reaction Time	.68	2	2.89	2
Tasks with Ratings ≥ 2.00				
25. Discrimination Reaction Time	.02	35	2.56	3
19. Punch Board*	.22	5	2.33	5
17. O'Connor*	.13	13	2.33	5
4. Two Plate Tapping*	.12	14.5	2.33	5
15. Purdue (both hands)*	.19	7.5	2.22	7.5
18. Santa Ana*	-.09	20	2.22	7.5
13. Purdue (right hand)*	.25	3	2.11	11.5
11. Minnesota (placing)*	.22	5	2.11	11.5
12. Minnesota (turning)*	.17	9	2.11	11.5
16. Purdue (Assembly)*	.15	11	2.11	11.5
14. Purdue (left hand)*	.02	35	2.11	11.5
27. Rudder Control	.02	35	2.11	11.5
5. Key Tapping*	.15	11	2.00	17
24. Rotary Pursuit	.10	12.5	2.00	17
7. Rotary Aiming*	.04	25	2.00	17
8. Hand Precision Aiming*	.04	25	2.00	17
20. Pin Stick*	-.03	30.5	2.00	17

Table 6

COMPARISON OF TASKS WITH HIGH FACTOR LOADINGS ON FACTOR 3 (RATE OF ARM MOVEMENT) AND HIGH MEAN RATINGS ON SCALE 29 (SPEED OF LIMB MOVEMENT)

	Factor Loading		Rating	
	Value	Rank	Value	Rank
Tasks with Factor Loadings $\geq .30$				
6. Ten Target Aiming	.66	1	1.33	11
4. Two Plate Tapping	.54	2	2.11	1
7. Rotary Aiming	.46	3	1.33	11
11. Minnesota (placing)	.36	4	.89	28.5
Tasks with Ratings $\geq$ 2.00				
27. Rudder Control	-.03	37	2.00	2

Table 7

COMPARISON OF TASKS WITH HIGH FACTOR LOADINGS ON FACTOR 4 (WRIST-FINGER SPEED) AND HIGH MEAN RATINGS ON SCALE 30 (WRIST-FINGER SPEED)

	Factor Loading		Rating	
	Value	Rank	Value	Rank
Tasks with Factor Loadings ≥ .30				
28. Medium Tapping	.74	1.5	2.89	15.5
29. Large Tapping	.74	1.5	2.78	19.5
31. Pursuit Aiming I	.50	3	2.67	21.5
32. Pursuit Aiming II	.48	4	2.67	21.5
30. Aiming	.45	5	2.89	15.5
4. Two Plate Tapping	.36	6.5	3.44	2
7. Rotary Aiming	.36	6.5	2.89	15.5
Tasks with Ratings ≥ 2.00				
5. Key Tapping*	.23	15	3.89	1
10. Auditory Reaction Time*	.10	30	3.33	3
19. Punch Board*	.25	13	3.22	4.5
20. Pin Stick*	.23	15	3.22	4.5
15. Purdue (both hands)*	.10	30	3.11	7.5
9. Visual Reaction Time*	.11	27.5	3.11	7.5
16. Purdue (Assembly)*	.17	22	3.11	7.5
14. Purdue (left hand)*	.19	20.5	3.11	7.5
13. Purdue (right hand)*	.11	27.5	3.00	11.0
17. O'Connor*	.13	26	3.00	11.0
12. Minnesota (turning)*	.20	19	3.00	11.0
8. Hand Precision Aiming*	.27	11	2.89	15.5
11. Minnesota (placing)*	.22	17	2.89	15.5
25. Discrimination Reaction Time	.16	23.5	2.89	15.5
18. Santa Ana*	.26	12	2.78	19.5
24. Rotary Pursuit	.21	18	2.33	23
6. Ten Target Aiming*	.06	33.5	2.22	24

Table 8

COMPARISON OF TASKS WITH HIGH FACTOR LOADINGS ON FACTOR 5 (FINGER DEXTERITY) AND HIGH MEAN RATINGS ON SCALE 33 (FINGER DEXTERITY)

	Factor Loading		Rating	
	Value	Rank	Value	Rank
Tasks with Factor Loadings ≥ .30				
15. Purdue (both hands)	.61	1	3.44	1
14. Purdue (left hand)	.58	2	2.44	6.5
16. Purdue (assembly)	.55	3	3.22	3
17. O'Connor	.53	4	3.33	2
13. Purdue (right hand)	.46	5	2.44	6.5
12. Minnesota (turning)	.34	6	2.22	8.5
11. Minnesota (placing)	.31	7	2.56	5
Tasks with Ratings ≥ 2.00				
18. Santa Ana*	.16	15	3.00	4
20. Pin Stick*	.20	11	2.22	8.5
19. Punch Board	.15	16.5	2.11	10

Table 9

COMPARISON OF TASKS WITH HIGH FACTOR LOADINGS ON FACTOR 6 (MANUAL DEXTERITY) AND HIGH MEAN RATINGS ON SCALE 34 (MANUAL DEXTERITY)

	Factor Loading		Rating	
	Value	Rank	Value	Rank
Tasks with Factor Loadings ≥ .30				
18. Santa Ana*	.47	1	2.44	6
12. Minnesota (turning)	.38	2	3.11	1
11. Minnesota (placing)	.32	3	2.44	1
Tasks with Ratings ≥ 2.00				
17. O'Connor*	.25	7	2.67	2
16. Purdue (assembly)*	.21	11	2.56	3.5
24. Rotary Pursuit	.17	17	2.56	3.5
15. Purdue (both hands)*	.21	11	2.44	6
20. Pin Stick*	.28	4.5	2.33	8
2. Steadiness Aiming	.03	32	2.22	9
13. Purdue (right hand)*	.19	14	2.11	10.5
14. Purdue (left hand)*	.13	20.5	2.11	10.5
19. Punch Board*	.21	11	2.00	12.5
3. Track Tracing	-.05	29	2.00	12.5

Table 10

COMPARISON OF TASKS WITH HIGH FACTOR LOADINGS ON FACTOR 7 (ARM-HAND STEADINESS) AND HIGH MEAN RATINGS ON SCALE 35 (ARM-HAND STEADINESS)

	Factor Loading		Rating	
	Value	Rank	Value	Rank
Tasks with Factor Loadings ≥.30				
3. Track Tracing	.61	1	3.67	3
2. Steadiness Aiming	.60	2	4.44	1
1. Precision Steadiness	.50	3	4.11	2
35. Steadiness	.31	4	2.89	5
Tasks with Ratings ≥2.00				
24. Rotary Pursuit	.16	7.5	3.22	4
19. Punch Board*	.30	5	2.44	7
8. Hand Precision Aiming*	.09	17.5	2.44	7
6. Ten Target Aiming*	.02	31.5	2.44	7
30. Aiming*	.01	35.5	2.00	9

Table 11

COMPARISON OF TASKS WITH HIGH FACTOR OADINGS ON FACTOR 8 (PSYCHOMOTOR COORDINATION) AN') HIGH MEAN RATINGS ON SCALE 37 (CONTROL PRECISION)

	Factor Loading		Rating	
	Value	Rank	Value	Rank
Tasks with Factor Loadings $\geq .30$				
24. Rotary Pursuit	.53	1	3.33	1
27. Rudder Control	.45	2	2.67	4
26. Complex Coordination	.36	3	2.44	5
Tasks with Ratings ≥ 2.00				
22. Postural Discrimination (Vertical)	.08	23	3.11	2.5
23. Postural Discrimination (Angular)	.05	28.5	3.11	2.5

with Arm-Hand Steadiness, where three tasks had loadings above .50 on this factor; all three of these were ranked 1 to 3 on the factor ratings made by the observers. On Control Precision (Table 11) three tasks had loadings above .36 and these three tasks received rankings of from 1 to 5 out of the 38 tasks rated on this ability. Thus, of the eight ability categories examined, six show good agreement between empirical loadings and independent observer ratings when examined in this manner. Two, Wrist-Finger Speed and Speed of Limb Movement, showed low agreement.

These tables (4 through 11) reveal another critical finding. The lower half of each table illustrates the occurrence of false positives on several ability scales. These are cases where an observer rated a task high on an ability scale, and the task turned out to have low empirical factor loadings on that ability. Thus, although tests with high factor loadings on an ability tend to get rated high in the observed ability, judges also have a tendency to give relatively high ratings to tasks with low factor loadings. This is particularly noticeable in Table 11 where the two Postural Discrimination tasks (Tasks 22 and 23) are given high ratings (ranks of 2.5 and 2.5) although their factor loadings are quite low (ranks of 23 and 28.5). Such false positive ratings constitute the primary rating error made by the judges and are the main reason that the correlations displayed in Table 3 are not higher. This problem is particularly troublesom with Reaction Time, Wrist-Finger Speed, and Manual Dexterity abilities. The precise reason for the occurrence of the false positive ratings is not clear and needs to be explored. Future work with more training of observers or in the wording of the scales may reduce the problem.

Inter-Judge Agreement

An additional statistic relevant to the utility of the ability rating scales is the intraclass correlation coefficient (Winer, 1962, p. 128). This coefficient (r_k) represents the inter-judge agreement associated with the ratings on three of the scales. It provides an estimate of the correlation

which would be obtained were the mean ratings of the present nine judges correlated with mean ratings of another random sample of nine judges rating the same tasks.* Table 12 summarizes these for the eight ability rating scales. It can be seen that the reliabilities expressed as intra-class correlations, for Choice Reaction Time, Reaction Time, and Speed of Limb Movement are so low as to indicate instability of the mean ratings on each of these scales. Therefore, the relationships between mean ratings on these scales and the factor loadings on the analogous factor should not be interpreted with the same confidence as can be had for the remaining scales. The low intra-class correlations may be largely attributed to the "false positive" problem previously described for several of these scales.

Predictive Validity

In order to determine whether the ratings of the tasks were correlates of performance on the tasks, a multiple regression technique was employed. A regression model was developed in which the mean task ratings on each of the scales were treated as predictor variables. The model was based upon the premise that mean ability ratings could be selected which represented correlates of performance and, as such, could be used to predict average performance levels on the different tasks.

One requirement for fitting the rating data in a regression model was that a common performance measure had to be available for each of the tasks utilized in the regression. Careful examination of the set

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*$r_k = \dfrac{kr_1}{1+(k-1)r_1}$ Where:

k = number of judges

$r_1 = \dfrac{\text{MS between tasks} - \text{MS within tasks}}{\text{MS between tasks} + (k-1)\,\text{MS within tasks}}$

Table 12

INTRACLASS CORRELATIONS FOR THE EIGHT ABILITY SCALES

Ability Scale	$\bar{r}_k$
27. Choice Reaction Time	.01
28. Reaction Time	.00
29. Speed of Limb Movement	.00
30. Wrist-Finger Speed	.64
33. Finger Dexterity	.78
34. Manual Dexterity	.76
35. Arm-Hand Steadiness	.78
37. Control Precision	.75

of tasks indicated that twenty-seven of the tasks (those marked with an asterisk in Table 2) provided performance data which could be converted to a common measure designated as the "number of units produced per unit time." The "units" varied among tasks and included such things as: number of openings negotiated, number of matchings accomplished, number of items completed, and number of pins placed. All of the tasks for which this common measure was available were speeded tasks in which a subject had to complete as many "units" as possible within a fixed period of time. Since the time period varied across tasks, a time base of one second was chosen and the mean performance scores reported in Fleishman's study were converted to the measure of average number of units produced per second. For example, on the Two Plate Tapping Test, 717.0 "units" (taps) produced in 180 seconds equaled 3.98 units per second.

In selecting ability scales for use as predictors of the average number of units produced per second on each of the 27 tasks, three criteria were employed. First, only those scales which exhibited high reliability, in terms of intraclass correlations, were considered for inclusion in the model. Second, any scale selected had to have enough variability in mean rating across the 27 tasks so as to provide for some discrimination among tasks and, hence, for some predictive relationship between the scales and the criterion variable. Third, the scales chosen had to possess some logical relationship to the performance on the tasks. This latter criterion became necessary because a large set of candidate variables resulted from the application of the first two criteria. Since there were only 27 observations on the criterion variable, only a subset of the predictors passing the first two criteria could be employed. In multiple regression the number of predictors should not approach the number of cases sampled. Wishart (1931) has pointed out that as the number of predictor variables approaches the total sample size, the multiple correlation coefficient

approaches one (1) even when the variates are uncorrelated in the population. The scales selected for analysis as a result of this procedure are shown in Table 13, together with their intraclass correlation coefficients re-calculated on the basis of just those 27 tasks used in this analysis.

A Wherry-Doolittle step-wise multiple regression was performed on the data presented in Table 14. Although six predictor variables were entered into the analysis, only three were fitted since the other variables failed to contribute significantly to the prediction of the criterion variable. The resulting regression equation is shown below in raw score form.

$$Y = 5.03 - 2.37X_{31} - 0.95X_{34} - 0.74X_{35} .$$

The multiple correlation coefficient associated with this equation was $R = 0.69$ ($F(3, 23) = 7.00$, $p < .01$). Gross Body Coordination, Manual Dexterity, and Arm-Hand Steadiness are the abilities getting the primary weights in this equation. Since the obtained multiple correlation was based on a sample of 27 cases, a correction for small sample bias (Guilford, 1956, p. 399) was applied. The corrected multiple correlation was 0.64 which was still significant beyond the 0.01 level of confidence ($F(3, 23) = 5.33$).

This analysis indicates that the abilities scales are indeed correlates of task performance and, therefore, may have possible future application as predictors of performance on tasks for which such data are not available. There is, of course, a need for cross-validation of these results and a replication of the study with other types of tasks. The present study presents some guidelines on methods for carrying out more comprehensive studies on the prediction of task performances from rated ability requirements.

Table 13

INTRACLASS CORRELATIONS FOR THE SCALES USED IN THE REGRESSION ANALYSIS

Ability Scale	$\underline{r}_k$
26. Gross Body Equilibrium	0.99
31. Gross Body Coordination	0.65
32. Multilimb Coordination	0.86
33. Finger Dexterity	0.75
34. Manual Dexterity	0.67
35. Arm-Hand Steadiness	0.43

DATA FOR REGRESSION ANALYSIS

	Tasks	Avg. No. of Units Produced Per Second	Average Ratings on the Ability Scales* 21 GBE	31 GBC	32 MC	33 FD	34 MD	35 AHS
4.	Two Plate Tapping	3.98	.00	.11	.22	.89	1.56	.56
5.	Key Tapping	6.24	.00	.22	.22	1.67	1.11	.22
6.	Ten Target Aiming	2.03	.00	.22	.22	.56	1.44	2.44
7.	Rotary Aiming	2.49	.00	.22	.22	1.56	1.22	1.33
8.	Hand Precision Aiming	1.87	.11	.11	.11	1.22	1.78	2.44
9.	Visual Reaction Time	4.07	.00	.11	.11	.56	.78	.44
10.	Auditory Reaction Time	4.29	.00	.11	.22	.44	.78	.33
11.	Minnesota (placing)	1.23	.00	.22	.00	2.56	2.44	1.44
12.	Minnesota (turning)	1.49	.00	.11	2.78	2.22	3.11	1.44
13.	Purdue (right hand)	.56	.00	.22	.22	2.44	2.11	1.67
14.	Purdue (left hand)	.54	.00	.11	.67	2.44	2.11	1.89
15.	Purdue (both hands)	.87	.00	.11	2.44	2.44	2.44	1.56
16.	Purdue (assembly)	.62	.00	.11	2.56	3.22	2.56	1.78
17.	O'Connor	.55	.00	.22	.22	3.33	2.67	1.44
18.	Santa Ana	1.80	.00	.11	.22	3.00	2.44	1.56
19.	Punch Board	1.49	.00	.22	.11	2.11	2.00	1.89
20.	Pin Stick	1.26	.00	.22	.78	2.22	2.33	2.44
21.	Dynamic Balance	.04	2.78	2.00	1.67	.44	.00	.33
28.	Medium Tapping	1.34	.00	.22	.22	1.22	1.78	1.00
29.	Large Tapping	1.26	.00	.56	.22	1.22	1.67	1.00
30.	Aiming	1.81	.00	.11	.22	1.44	1.44	2.00
31.	Pursuit Aiming I	2.32	.00	.33	.11	1.67	1.56	1.44
32.	Pursuit Aiming II	1.76	.00	.11	.44	1.44	1.56	1.33
33.	Square Marking	1.16	.00	.11	.22	1.11	1.22	1.22
34.	Tracing	1.89	.00	.11	.00	1.11	1.89	1.89
36.	Discrimination Reaction Time (printed)	.38	.00	.22	.00	.89	1.11	.44
37.	Marking Accuracy	1.37	.00	.22	.11	.89	1.56	1.00

*Scales are: 26, Gross Body Equilibrium; 31, Gross Body Coordination; 32, Multilimb Coordination 33, Finger Dexterity; 34, Manual Dexterity; 35, Arm-Hand Steadiness.

CONCLUSIONS

This study focused upon a test of the validity of an approach to the development of a comprehensive taxonomy of tasks based upon the use of known parameters of human performance for describing and classifying tasks. Two independent estimates of its validity were obtained. First, the results of this preliminary research indicate that judges' ratings of tasks on human ability dimensions, in the Task Assessment Scales instrument, (TAS) bear a substantial degree of relationship to the empirically derived factor loadings for those same tasks on factors analogous to the ability scales. Second, the ratings of tasks on the ability dimensions were shown to be predictive of task performance. While these results have to be interpreted in light of the preliminary nature of the research, they are encouraging with respect to the development of a human abilities based taxonomy. Coupled with the results of an earlier pilot study (Theologus, Romashko, & Fleishman, 1970), the results indicate that the TAS can serve to reliably and validly describe, classify, and predict human performance on a variety of tasks. However, some scales need to be improved.

Of the eight abilities investigated, Reaction Time, Wrist-Finger Speed, Finger Dexterity, Manual Dexterity, Arm-Hand Steadiness, and Control Precision seem to provide the most dependable areas for the use of ability requirement ratings, based on joint considerations of their correlations with factor loadings across tasks, the more stringent test of similarity coefficients, and reliability as reflected by intraclass correlation coefficients. Reaction Time would drop out of this list if we emphasized its low intraclass correlation. The prime reason for the latter finding is the number of "false positives" found for Reaction Time. The problem of false positives (ascribing high ability requirements to tasks where the abilities have low factor loadings) was shown to exist for several scales. This problem could probably be minimized through additional training or revised instructions to raters.

The results of the research highlighted several other problems in the use of the TAS which suggest additional avenues for its further development. Higher reliabilities are required to provide more stable estimates of the ratings of a task on the ability dimensions. Low reliabilities were obtained on several of the scales employed in the research. Until these reliabilities can be increased, rather large panels of judges will be necessary to obtain stable estimates of a task's ratings. One method of improving the reliabilities would be to employ panels of judges trained in the use of the TAS, rather than the randomly selected university students employed in the present study.

The requirements in the regression model for a common performance metric across tasks placed constraints on the number of tasks which could be utilized in the analysis. In future research, this problem can be alleviated in either of two ways. Rather than utilizing data reported in the literature, actual performance data can be collected on a large sample of tasks, all of which possess a common measure of performance. Another solution to this problem would be to engage in additional research which attempts to identify the smallest possible set of measures which can serve to represent all possible measures (see for example, Teichner and Olson, 1969, Teichner and Whitehead, 1971).

In summary, the present study provides an indication of the value of the abilities approach to task classification and argues for the continued development of this approach.

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APPENDIX A

EXAMPLES OF ABILITY RATING SCALES FROM THE TASK ASSESSMENT SCALES

27. CHOICE REACTION TIME

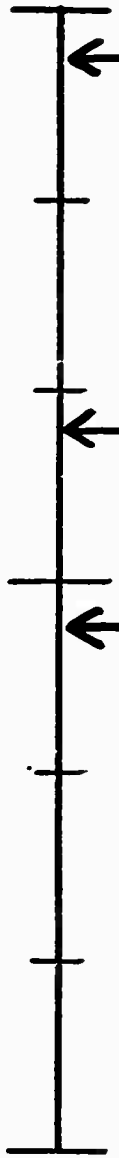
This is the ability to select and initiate the appropriate response relative to a given stimulus in the situation where two or more stimuli are possible and where the appropriate response is selected from two or more alternatives. The ability is concerned with the speed with which the appropriate response can be initiated and does not extend to the speed with which the response is carried out. This ability is independent of mode of stimulus presentation (auditory or visual) and also of type of response required.

CHOICE REACTION TIME DISTINGUISHED FROM OTHER ABILITIES:

Involves speed of response initiation when response involves selection from two or more alternatives relative to two or more stimuli.	vs.	Reaction Time (28): Involves speed of response initiation when there is a single response associated with a single stimulus.
		Speed of Limb Movement (29) and Wrist Finger Speed (30): Deal with the speed with which a movement or response can be made once initiated.

27. CHOICE REACTION TIME

Requires the selection of the correct response from many alternatives and the initiation of the response with such extreme speed that it could be expected from only an extremely limited number of people.



In a space craft out of control, an astronaut has time to choose only 1 of 5 possible corrective actions in 0.7 seconds.

Operate a busy PBX or switchboard where you start to answer each call in 1 second on the average.

Select the correct fork in the road when the road sign is located at the center of the fork itself and where you have 1 second to make your choice.

Requires only enough speed to select the correct response from two alternatives and to initiate that response when time constraints are minimal.

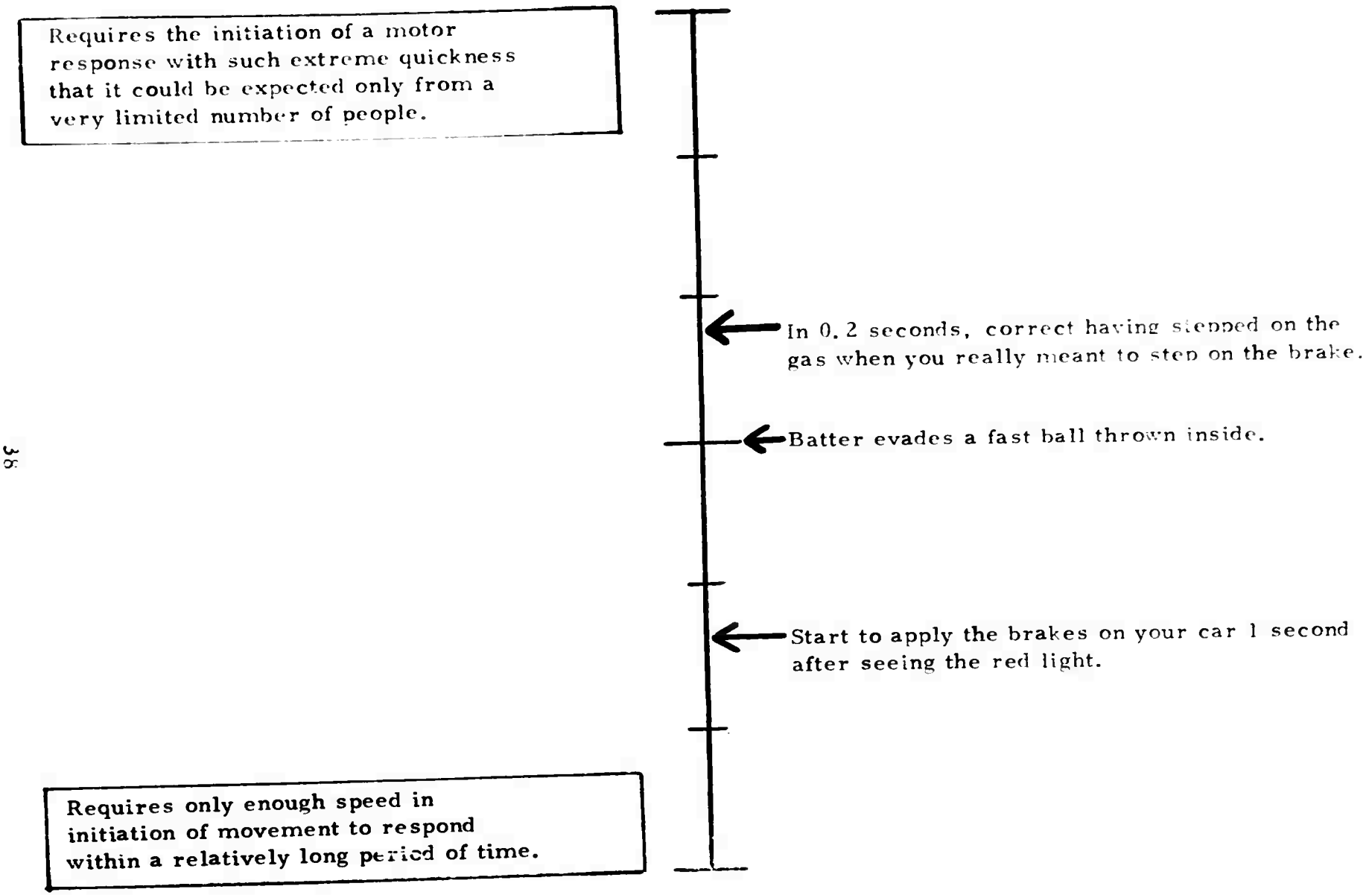
28. REACTION TIME

This ability involves the speed with which a single motor response can be initiated after the onset of a single stimulus. It does not include the speed with which the response or movement is carried out. This ability is independent of the mode of stimulus presentation (auditory or visual) and also of the type of motor response required.

REACTION TIME DISTINGUISHED FROM OTHER ABILITIES:

Deals with the speed with which a single motor response can be initiated relative to a single stimulus.	vs.	Choice Reaction Time (27): Involves speed of response initiation when response involves selection from two or more alternatives relative to two or more stimuli.
		Speed of Limb Movement (29) and Wrist Finger Speed (30): Deal with the speed with which a movement or response can be made once initiated.

28. REACTION TIME



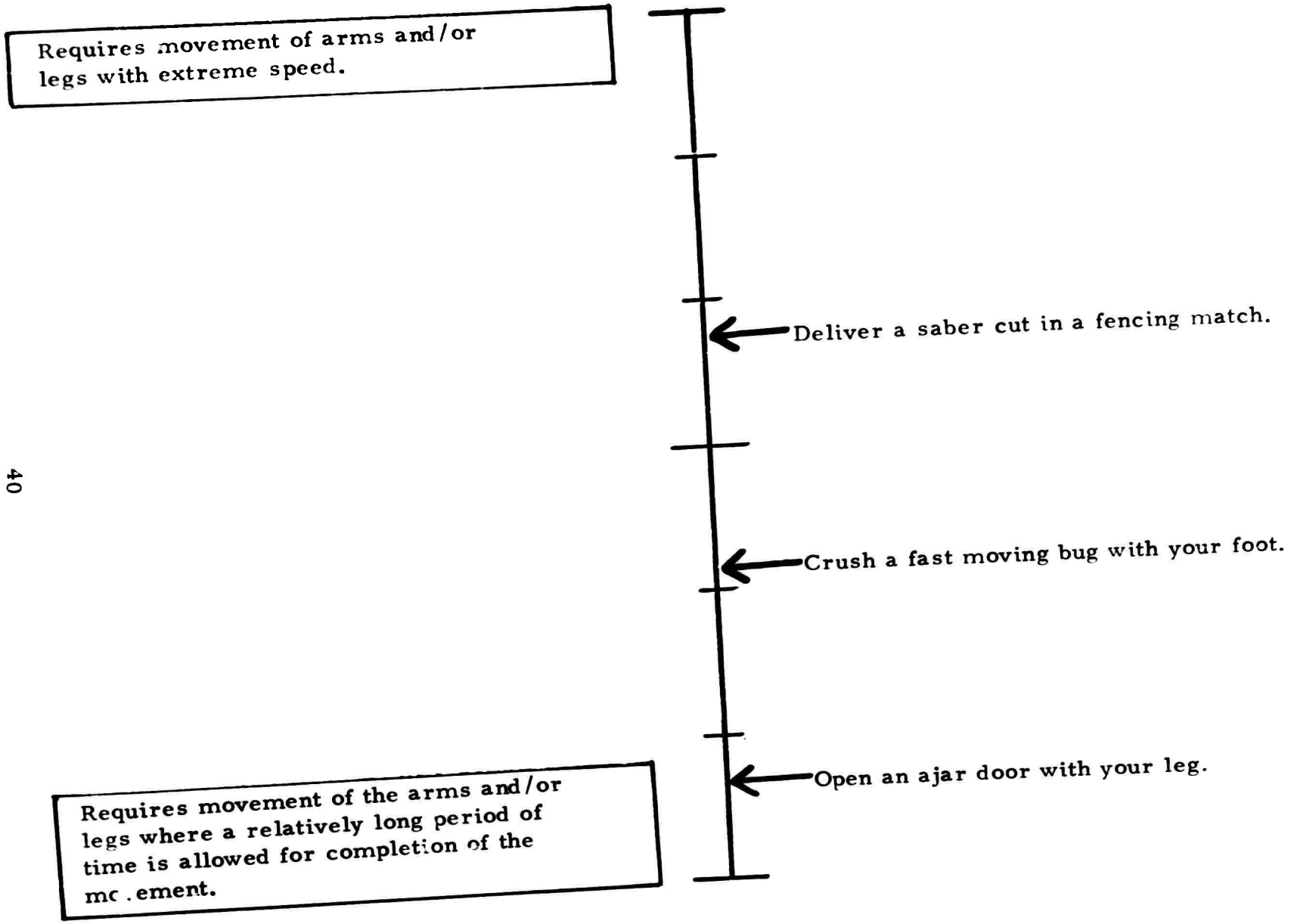
29. SPEED OF LIMB MOVEMENT

This ability involves the speed with which discrete movements of the arms or legs can be made. The ability deals with the speed with which the movement can be carried out after it has been initiated; it is not concerned with the speed of initiation of the movement. In addition, the precision, accuracy and coordination of the movement is not considered under this ability.

SPEED OF LIMB MOVEMENT DISTINGUISHED FROM OTHER ABILITIES:

Speed to carry out a movement or response, once initiated.	vs.	Reaction Time (28) and Choice Reaction Time (27): Involve speed of response initiation.
Speed of movement of arms or legs.	vs.	Wrist-Finger Speed (30): Speed of movement of fingers, hands, and wrists.
Speed of movement of arms.	vs.	Manual Dexterity (34): Skilled, controlled arm-hand movements.

29. SPEED OF LIMB MOVEMENT



APPENDIX B

INSTRUCTIONS TO THE JUDGES AND TASK DESCRIPTIONS

Adapted from Fleishman (1954)

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INSTRUCTIONS

The kit of materials before you consists of the following items: 1) a reference manual, 2) a set of task descriptions, and 3) a set of answer sheets for each of the task descriptions. You will be asked to analyze each of the task descriptions in terms of the thirty-seven descriptors of human abilities contained in the reference manual. As you analyze a task in terms of each of the abilities, you will mark your ratings of the task on the answer sheets.

In rating the task descriptions you will be making two different decisions. First, you must decide whether the ability, as it is defined in the manual, is required for performance on the task you are rating. Second, if you decide that the ability is required, you must determine the extent or degree to which it is required. The result of your effort will be a quantitative profile of the task in terms of these human abilities required for its performance.

In analyzing the task descriptions the following procedure will be employed.

First, read the task description thoroughly and with extreme care. Be certain that you fully understand all of the activities in which an operator or subject must engage to complete the task. If possible, you should actually attempt to visualize these activities and go through them one by one. When you fully understand the task description, you may begin to analyze it in terms of the abilities in the reference manual.

Second, open your reference manual to pages one and two which contain the first ability descriptor. Begin by reading the material presented on the left-hand page. This page presents the name of the particular ability descriptor, a definition of it, and a chart which distinguishes the ability you are considering from other abilities which are either similar to it or can easily be confused with it. The definition of the ability was developed expressly to present the precise nature of the ability and to reveal its scope and its limits. The chart below the ability definition is presented as a further aid in determining the extent of the ability. This chart is necessary since some abilities differ from each other in only one or two critical aspects and therefore, might easily be confused.

When considering the information presented on this page, it is quite important to focus your attention upon the definition of the ability and upon the chart of distinctions rather than upon the name of the ability. It is quite possible that you have encountered this name in a different context where it had a different meaning. If you focus too much attention upon the name of the ability, this past familiarity with the name will interfere with your rating of the task.

Having considered the information on this page to the point where you completely understand the ability as it is defined, you are ready to make the first decision concerning this ability.

Third, based upon your understanding of the ability you must decide whether this ability is required for performance on the task you are considering. If your decision is NO, check the box marked DOES NOT APPLY on your answer sheet for that ability. Having done this, ignore the right-hand page and proceed to the next ability description and begin your analysis of the task with respect to that description.

If, on the other hand, you decide that some amount of this ability is required for performance on the task, you must determine the amount of the ability which is required. To do this proceed to the right-hand page.

Fourth, on the right hand page you will find a seven-point scale relating to the ability defined on the left-hand page. General definitions of the high and low levels of the ability are presented to the left of the scale while to the right are examples of tasks which display different amounts of the ability. The definitions present the critical factors which determine the amount of the ability required. In other words, more than one aspect of the task may determine the amount of the ability which is required.

Take for example an ability which is affected by two aspects of the task. A scale rating of medium could be achieved by the ability being medium on both of the underlying dimensions or by being high on one and low on the other. It should be noted that not all of the abilities vary over multiple dimensions.

The examples which are placed along the right-hand side of the scale serve as concrete anchors for the scale. They are there to provide you with reference points for rating the task you are considering. They should be employed by asking the question "Does the task which I am considering require more or less of the ability than this example?"

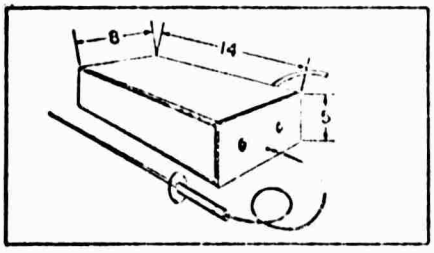
In rating the task, you are attempting to estimate the lowest amount of the ability a subject could possess and still produce errorless performance on the task. Two points are important here. First, it is possible that if X amount of the ability will yield errorless performance, an amount greater than X will also yield errorless performance. Therefore, keep in mind that you are asked to estimate X or the lowest amount which will still produce errorless performance. The second point is that you are considering the amount of the ability required for performance and not that required for the learning of the task. You must assume that the subject has already learned the task and that he is now performing it at an errorless level.

Once you have reached a conclusion as to the amount of the ability required by the task you are rating, mark your answer by placing an "X" on the rating scale on the answer sheet. Please remember to use the scale on the answer sheet and not the one in the reference manual.

Five, continue the procedures outlined above until you have rated the task with respect to all thirty-seven abilities presented in the reference manual.

TASK 1: Precision Steadiness

Apparatus



Description

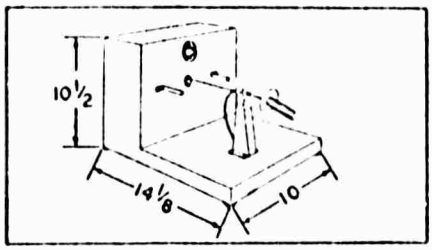
The S is seated before a long rectangular boxlike apparatus containing two openings. Each opening is the entrance to a straight passageway which S must negotiate with a long stylus. He moves the stylus forward at slightly below shoulder height and at arm's length. He must move the stylus slowly and steadily away from his body, trying not to hit the sides of the cylindrical passage. As he reaches the end of the passage he strikes a contact point and withdraws the stylus, again trying to avoid hitting any part of the passageway. He then negotiates the second passageway. Two complete negotiations constitute a trial. Counters record the number of contacts and clocks record the amount of time in contact. Six trials, no time limit.

Instructions

Your task is to move this stylus slowly and carefully arms length through the openings. You are to do this without touching the sides of the passageway with the stylus. When the stylus makes contact with the end of the passageway, withdraw it carefully and slowly without touching the sides. When you have moved the stylus in and out of opening No. 1, move to opening No. 2 and repeat the procedure. After moving in and out of the second passageway, place the stylus beside the machine and rest until told to continue. You will repeat the procedure. Are there any questions?

Remember to keep the stylus at arms length at all times and to move as carefully as possible to reduce errors which is time you contact the sides of the passageway. Begin when I say 'Start'.

Apparatus



Description

The subject must keep a delicately balanced stylus centered in a small hole. Errors are recorded whenever contact is made with the sides of the hole. Any contact with sides of the hole is recorded on a clock. The error score is the number of seconds in contact. The subject sits throughout the test. Six 40-sec. trials.

Instructions

Take hold of the handle in your preferred hand, with your thumb up. Place your shoulders flat against the back of your chair. Adjust your chair so that you are holding the handle with your arm out straight.

Now let the handle rest in its holder. Do not let it slide forward or back, or press down. This is a test of how well you can keep the rod in this hole without touching the edge. Whenever you touch the edge, the light will come on. As long as the light is on, errors are counting against you. Do not move the rod forward or backward as this will also count as an error against you.

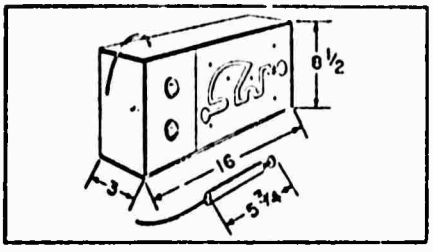
You will have several test periods with rests in between.

When I say "READY", take hold of the handle and raise the rod to the proper position in the center of the hole. When I say "START", your score will begin to count.

Are there any questions?

TASK 3: Track Tracing

Apparatus



Description

The S is required to negotiate an irregular slot pattern with a T-shaped stylus. He sits at arm's length from the apparatus box and moves slowly and steadily through the pattern from right to left, depresses a plunger at the end of the pattern with his stylus, and then returns through the pattern. This constitutes one trial.

Errors are recorded each time any part of the stylus touches the top, bottom, or back of the slot. Six trials, no time limit.

Instructions

Your task is to move the stylus at arms length slowly and carefully through this slot. You are to do this without allowing the stylus to touch the top, bottom, or inside of the slot. Any time the stylus touches any part of the metal plate around the slot, errors will be automatically counted against you. The red light tells you when you are making errors. When you get to the end of the slot, push in on the little plunger with your stylus, and then retrace the pattern without removing the stylus from the slot. When you have completed tracing back through the slot, put your stylus down and place your hand in your lap. Rest until told to begin.

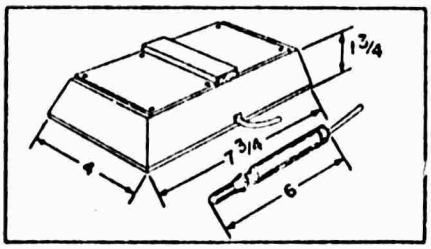
Remember, it is important that you move slow enough so that you may avoid hitting any part of the slot.

Are there any questions?

Pick up the stylus and begin when the green light goes on.

TASK 4: Two Plate Tapping

Apparatus



Description

The S is required to strike two adjacent metal plates with a stylus as rapidly as possible. He strikes the plates successively; that is, first one then the other, making as many taps as possible on the plates in the time allowed. The number of taps is recorded on counters. Six 30-sec. trials. The subject stands throughout the test.

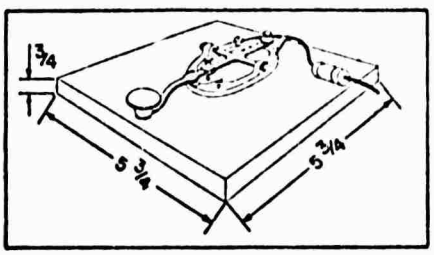
Instructions

This is a test to see how fast you can tap this stylus on the metal plates. Pick up the stylus with your preferred hand and place its point on the space between the two plates before you. At the signal "GO" begin tapping the plates alternately as rapidly as you can, starting with the left hand plate. Continue tapping as rapidly as you can until you are told to stop. You will get several rest periods during the test. Be careful not to shift your body to any new position after you have begun to tap. Try to work as fast as possible. Do not hit the position between the plates as you tap from one plate to the next. You will be penalized in your score if you do this too often.

Remember, tap the two plates successively as fast as you can.

TASK: 5 Key Tapping

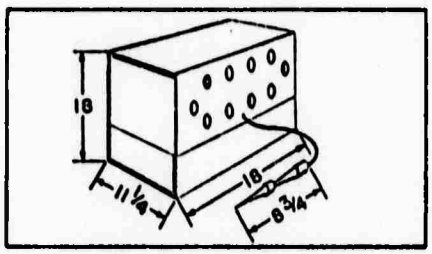
Apparatus



Description

The S stands by a standard telegraph key and must tap the key as rapidly as possible with the index finger. The number of taps is recorded on counters. Six 30-sec. trials.

Apparatus



Description

The S is seated before an upright panel containing ten holes arranged at equal intervals in an elliptoid pattern. Behind each hole can be seen a circular target. These targets vary in size from hole to hole. The S is required to strike at these targets with a stylus, moving from target to target around the pattern of targets in a clockwise direction. He makes only one strike at a time in each hole as he moves around the pattern. He is instructed that both speed and accuracy count and that he must try to hit as many targets as possible, moving as quickly as possible from target to target. Error counts are recorded each time S strikes the outside of each hole or inside around the target area. Correct counts are scored each time S hits within the target area in each hole. Six 30-sec. trials.

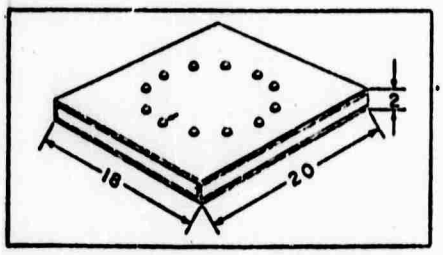
Instructions

This is a test to see how fast and accurately you can strike a series of targets. You will use this stylus with your preferred hand. When I tell you to start, your task will be to strike at these targets in the holes you see before you. You will notice that these targets vary in size. You should try to hit in the center of each target. You must move from one target to the next around the panel as quickly as you can, making only one thrust at each target.

You will be scored on the number of targets you hit accurately. You will also be scored for the number of misses. These will be recorded every time you hit outside the target or on this outside plate. When I say READY, pick up your stylus in the correct position. When I say GO start at this target and work as quickly and accurately as you can until told to stop. You do not have to hit the target hard to obtain a count.

TASK 7: Rotary Aiming

Apparatus



Description

The S stands before a horizontal panel containing 12 buttons which extend 1/8 inch above the panel and are arranged in a circular pattern. The S is required to strike each button with the index finger, moving from button to button in a clockwise direction. He makes only one strike at each button each time as he continues around the circular pattern, as rapidly as possible, until told to stop. Score is the number of strikes in the time allowed. Six 30-sec. trials.

Instructions

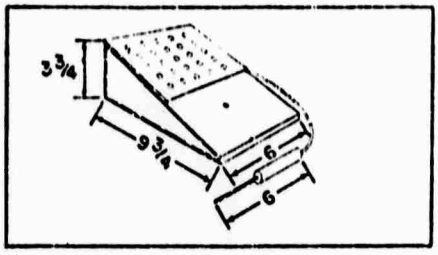
This is a test of your speed and precision of movement. Your task is to strike these small buttons precisely and as quickly as you can. You will start with the button at the arrow. When I say go, start striking the buttons with the top of your index finger while moving from button to button in a clockwise direction. You must strike the buttons in succession. If you miss a button, go back and strike it before going on to the next one, you will be penalized for skipping a button. Continue around the board until told to stop. Work as quickly and accurately as you can. Remember, use only the top of your finger of your preferred hand. Remember, speed is the important thing!

Are there any questions?

Ready: Go!

Task 8: Hand Precision Aiming

Apparatus

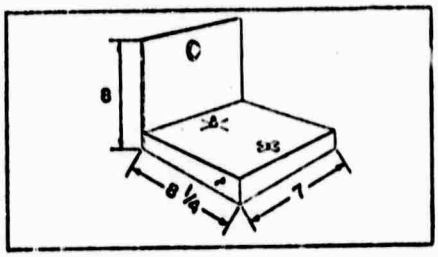


Description

The S is seated before a small panel consisting of two metal plates. The plates are tilted toward S from the horizontal position. The upper plate contains 25 holes 3/8 inch in diameter in five rows of five holes each. All holes are equidistant from each other (from center to center). The S has a small stylus with which he must punch in the holes striking the lower plate. He moves from hole to hole across one row and then across the next as rapidly as possible. He is instructed to aim accurately with each punch but to work as rapidly as possible. Every time he strikes the upper plate, an error count is recorded. Every time he strikes the lower plate, the correct count is recorded. Six 30-sec. trials.

TASK 9: Visual Reaction Time

Apparatus



Description

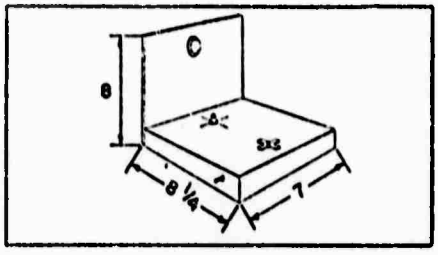
The S is seated before an upright panel containing a single amber light. He is required to respond as rapidly as possible when the light appears. He responds by striking a button with his hand which turns off the light. Before the light appears, he must keep his hand on a small cross located 6 inches in front of the button. A click provides him with a ready signal before each light stimulus is presented. The foreperiod (between click and light) varies in a random order from .5 to 1.5 sec. Score is the cumulated reaction time between the appearance of the stimulus and completion of the response for each setting. The S receives two trials consisting of twenty reactions each.

Instructions

This is a test of the speed with which you can react to a signal. Place the index finger of your preferred hand on the metal cross at the edge of the baseboard. Always return your finger to this position after each trial. Your task is to press the button as soon as you see the light come on in front of you. You must not jump the gun before the stimulus appears or you will be penalized for it. After you have pressed the button, return your hand to it's original position as quickly as possible and get ready for the next trial. Are there any questions?

TASK 10: Auditory Reaction Time

Apparatus



Description

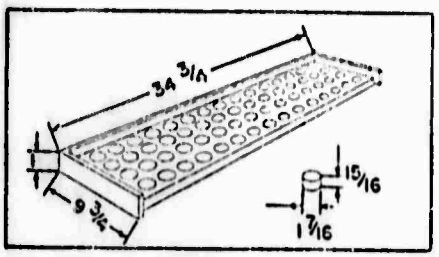
The S is seated before an upright panel containing a single buzzer. He is required to respond as rapidly as possible when the buzzer begins. He responds by striking a button with his hand which turns off the buzzer. Before the buzzer begins, he must keep his hand on a small cross located 6 inches in front of the button. A click provides him with a ready signal before each buzzer stimulus is presented. The foreperiod (between click and buzzer) varies in a random order from .5 to 1.5 sec. Score is the cumulated reaction time between the appearance of the stimulus and completion of the response for each setting. The S receives two trials consisting of twenty reactions each.

Instructions

This is a test of the speed with which you can react to a signal. Place the index finger of your preferred hand on the cross at the edge of the baseboard. Always return your finger to this position after each trial. Your task is to press the button as soon as you hear the buzzer. You must not jump the gun before the stimulus appears or you will be penalized for it. After you have pressed the button, return your hand to it's original position as quickly as possible and get ready for the next trial. Are there any questions?

TASK 11: Minnesota Rate of Manipulation (placing)

Apparatus



Description

The S is required to place 60 cylindrical blocks in the proper holes as rapidly as possible. Score is the number of blocks placed. Two 40-sec. trials.

The starting position for the blocks and for the board with the holes in it is achieved in the following fashion. The board, filled with the blocks, is slid so that the bottom edge of the board touches the guide line on the table. Next, the board is lifted off the blocks so as to leave them in position. As the board is lifted the blocks pass through the holes and remain in place on the table.

Finally place the empty board between the subject and the blocks so that the top edge of the board touches the guide line and so that the appropriate holes in the board line up below the blocks. This is the starting position for the test.

Instructions

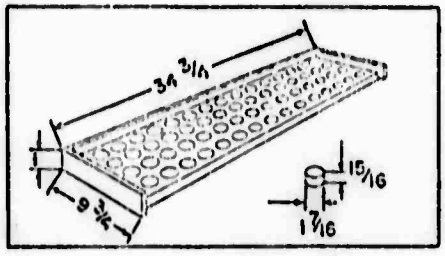
"The object is to see how fast you can put the blocks back into the holes with one hand. Use whichever hand you prefer. You do it like this.

"Begin on your RIGHT; put the bottom block in the top hole, the next block in the next hole, and (rapidly) so on right down the board."

"You may hold down the board with the other hand if you wish. Remember, you pick them UP in this order (tap the blocks in 1-2-3-4 order upward from the examinee) and put them DOWN in this order (tap the holes in the board in 1-2-3-4- order downward to the examinee). Before you finish be sure that every block is all the way down."

TASK 12: Minnesota Rate of Manipulation (turning)

Apparatus



Description

The S is required to remove the blocks from the holes with one hand, turn them over with the other hand, and replace them in the same holes, moving from block to block as rapidly as possible. Score is the number of blocks turned. Two 35-sec. trials.

In the starting position, the board filled with the blocks is placed in front of the S.

Instructions

The object is to see how fast you can turn the blocks over.

"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."

"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."

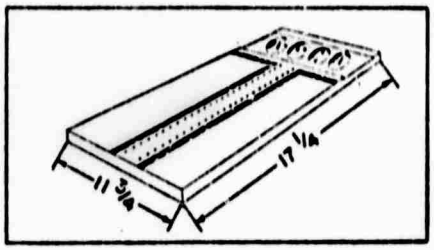
Having finished the top row, you go down to the next row and work back to the right.

"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."

"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."

TASK 13: Purdue Pegboard - Right hand

Apparatus



Description

The S is required to place a number of small pins individually in a series of small holes as rapidly as possible with the right hand. Score is the number of pins placed. One 30-sec. trial.

Instructions

Pick up one pin at a time with your right hand from the right cup. Place it in the top hole in the right hand column of holes. Place the next pin in the next hole down, and so on.

Now you insert a few pins for practice.

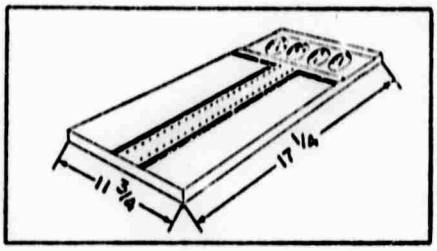
Take out the pins and put them back in the right hand cup. When I say "Begin" place as many pins as you can in the right hand column, starting with the top hole. If you finish the right hand column, start up the left hand column beginning with the bottom. Keep working just as rapidly as you can until I say "STOP".

Are there any questions?

Are you ready? BEGIN!

TASK 14: Purdue Pegboard -
Left hand

Apparatus



Description

The S is required to place a number of small pins individually in a series of small holes as rapidly as possible with the left hand. Score is the number of pins placed. One 30-sec. trial.

Instructions

Pick up one pin at a time with your left hand from the left cup. Place it in the top hole in the left hand column of holes. Place the next pin in the next hole down, and so on.

Now you insert a few pins for practice.

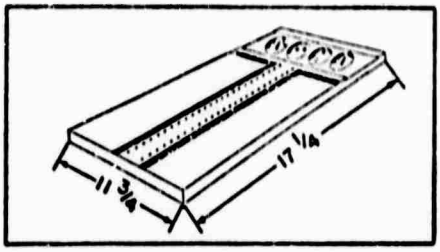
Take out the pins and put them back in the left hand cup. When I say "Begin" place as many pins as you can in the left hand column, starting with the top hole. If you finish the left hand column, start up the right hand column beginning with the bottom hole. Keep working just as rapidly as you can until I say "STOP".

Are there any questions?

Are you ready? BEGIN!

TASK 15: Purdue Pegboard -
Both hands

Apparatus



Description

The S is required to pick up two pins at a time, one with each hand from different trays and place them simultaneously in two different holes. Score is the number of pins placed. One 30-sec. trial.

Instructions

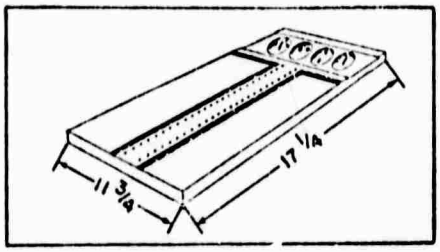
In this part of the test you will use both hands at the same time. Pick up a pin from the right hand cup with your right hand, and at the same time pick up a pin from the left hand cup with your left hand and place the pins down the columns. Begin with the top hole of both columns.

Now insert a few pins with both hands for practice. Go ahead. STOP! take out the pins and put them back in the proper cup. When I say "Begin", place as many pins as you can with both hands, starting with the top hole of both columns. Keep working just as rapidly as you can until I say "STOP".

Are you ready? BEGIN!

TASK 16: Purdue Pegboard - Assembly

Apparatus



Description

The S is required to make as many completed pin-washer-collar-washer assemblies as possible in the time allowed. Score is the number of assembly components completed. One 60-sec. trial.

Instructions

If you are right (left) handed you will pick up a pin from the right (left) hand cup with your right (left) hand and place it in the top hole of the right (left) column.

As you are doing this pick up a washer with your left (right) hand. And as soon as the pin has been placed in the hole, drop the washer over the pin.

While the washer is being placed with the left (right) hand, pick up a collar with your right (left) hand. Place this over the pin and washer.

As you are doing this pick up another washer with your left (right) hand and drop it over the pin and collar. This completes a single assembly.

As soon as the final washer is being placed with the left (right) hand start the second assembly by taking another pin with your right (left) hand and placing it in the next lower hole.

As you are doing this take another washer with your left (right) hand and place it on the pin. While doing this take another collar with your right(left) hand and place it over the pin. And as this is being done pick up another washer with your left (right) hand and place it over the pin with the collar to complete the second assembly.

TASK 16 (Continued)

Remember don't stop after putting on the final washer but immediately pick up another pin with your right (left) hand and place it in the next empty hole.

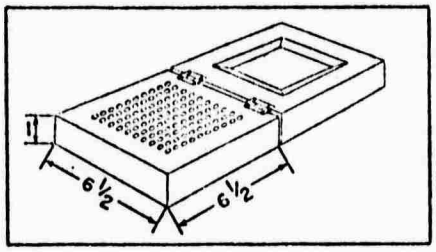
Also only pick up one piece at a time. Don't pick up several washers and keep slipping them on. Pick up one piece at a time.

When I say 'ready', put your hands over the cups you are first going to use. When I say 'Go', make as many assemblies as you can beginning with the top right (left) hole. Keep working as rapidly as you can until I say 'Stop'.

If you drop any piece forget about it and immediately start on a new assembly by picking up a pin with your right (left) hand and placing it in the next empty hole.

Any questions? O.K. Let's start the trial. Ready? Go!

Apparatus



Description

The S is required to pick up three small pins at a time from a tray of pins with the preferred hand and place them three at a time in a small hole. He must fill a series of small holes in this manner as fast as possible. Score is the number of pins placed. One 5-min. trial.

Instructions

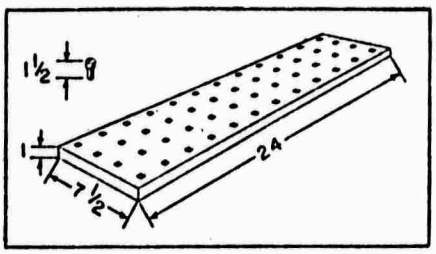
This is a test to see how fast and accurately you can work with your fingers. Your task is to fill the holes in this board with the pins from this tray.

Pick up three pins at a time and fill the holes, placing three pins in each as fast as you can. Use only one hand and put only three pins in each hole. Start in the upper left hand corner and work to the right.

Fill each row completely before you start on the next row. Do not skip around. Do not stop to pick up pins you drop. Use only one hand and pick up only three pins at a time.

READY? Go!

Apparatus



Description

The S is required to rotate a number of square pegs (with circular tops) 180° in their holes moving from peg to peg as rapidly as possible. Score is the number of pegs rotated. Two 35-sec. trials.

Instructions

This is a speed test. Your task will be to turn these pegs as fast as you can. (Demonstrate at one peg per second). When I say "Go", start with the first peg and work across the row to the left (motion), then start the second row, and so on. When I say "Stop", if you have a peg in your hand, place it in its hole and put your hand in your lap. Do you have any questions?

Go to the peg board which corresponds to your number. You will do best if you do not sit too close to the table. Adjust your chairs if you want to.

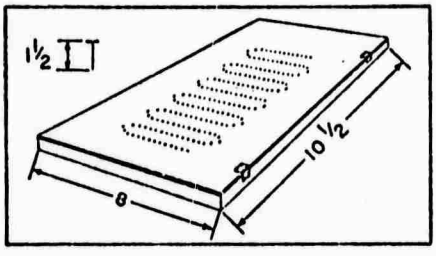
We will now have a practice period. Keep the hand you are not using in your lap and use your preferred hand. Remember, the pegs must be turned in a clockwise direction, and must be turned half way around to count in your score. Ready; Go! (35 seconds)

Stop! If you have a peg in your hand, put it in its hole and put your hand in your lap. Now, complete the board and replace any pegs that are out.

We will now have the first of two test periods. Your score will be the number of pegs turned in both of the test periods. Only pegs that are correctly turned will count in your score. Remember to work as fast as you can. Ready; Go! (35 second test periods)

TASK 19: Punch Board

Apparatus



Description

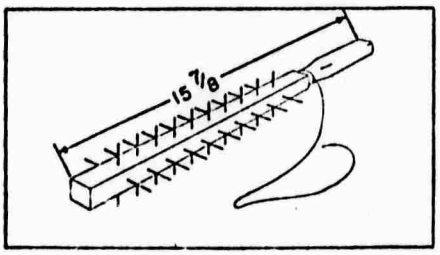
The S is presented with a small board covered by a hinged metal plate. This plate contains a pattern of tiny pin holes spaced very close together. The S is required to punch through the holes with a small pin, punching from hole to hole as rapidly as possible around the pattern. His punches are recorded on a sheet of marked paper which fits under the plate. Score is the number of punches. Two 60-sec. trials.

Instructions

On this board, you will note a pattern of tiny pin holes spaced very close together. Your task is to take this pin in your preferred hand and punch through each hole as rapidly as possible. Start at the top of the pattern when I say "GO". Stop when I say "STOP".

TASK 20: Pin Stick

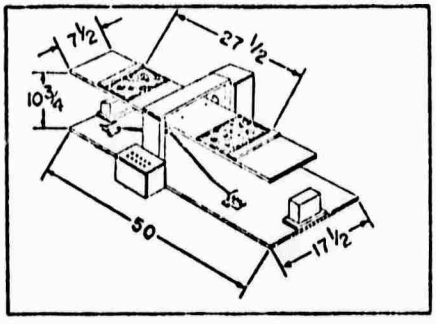
Apparatus



Description

The S holds a rod containing four rows of pins on each of four sides. He is required to take the thread attached to the bottom of the rod and to make one loop around each pin as rapidly as possible going from pin to pin, up and then down the stick. Score is the number of pins threaded. Four 15-sec. trials.

Apparatus



Description

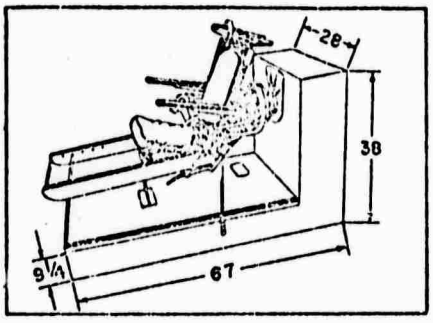
The S stands on a teeter-totter platform. Next to the platform is a panel of two parallel rows of five lights each. A red stimulus light appears in one of the rows and S is required to shift his weight on the platform in order to match up a green light in the other row with the stimulus light. The position of the green light is controlled by the position of the platform. When the platform is tilted appropriately and a correct matching is achieved and held for a short time delay, the stimulus light shifts to another position. He must accomplish as many of these matchings as possible. Score is the number of matchings accomplished and the amount of time spent in the correct positions. Four 2-min. trials.

Instructions

You will notice on this panel, there is a red light and a green light. When I move the board, the green light moves the same way. When I hold the board steady, the light remains steady. When I bring the lights together and hold them a moment, the red light moves. Your task will be to make as many of these matchings as you can during the test periods, while standing on the board. When I say, "Get ready", you will step upon the board with your feet against the insides of these small boards. Your weight will be on your left foot at the start of each test period. Any questions? Get ready for your first test period. Step up on the apparatus. You will not use any walls to steady yourself during the test and will stand fairly straight. When the lights appear you will begin work immediately. Step off the apparatus and relax until told to get ready. When the lights appear, begin to work immediately.

TASK 22: Postural Discrimination
Vertical

Apparatus



Description

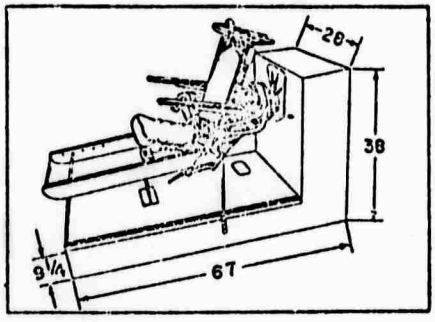
The S sits in a tilting chair arrangement which can be displaced to various positions by the administrator. The S is blindfolded and strapped into the chair. His task is to return the chair as closely as possible to the perceived upright position. He readjusts the chair by means of buttons on the arm rests. Score is the average deviation (number of degrees) of S's readjustment from the "true" upright position. Twelve trials (displacements), no time limit.

Instructions

This is an experiment to see how well you can adjust yourself to an upright position after you are placed in a tilted position. I will first tilt you to some inclined position and when I instruct you to do so, you are to return the chair as nearly as you can to the position in which you are now. You can move the chair by pressing these buttons in the arm rests. Push the right button to move to the right, and the left button to move to the left. When you are satisfied that you are in an upright position, say 'level'. Following this you will be placed in another tilted position and again you will be asked to return to an upright position. Each time try to come as close as you can to a perfectly upright position.

TASK 23: Postural Discrimination
Angular

Apparatus



Description

S is displaced to a given angular position, held in that position briefly, and told to remember it. He is then displaced and is told to reproduce that position as closely as possible. Score is the average deviation (in degrees) from the correct position. Twelve trials (displacements), no time limit.

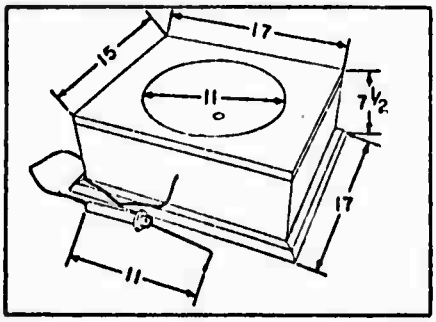
Instructions

This is a test to see how well you can judge your body position. First I will set the chair at a certain angle and hold it there for a few seconds. While the chair is in this angle, you should try to familiarize yourself with this position. I will then move the chair in the opposite direction. Then when I tell you to start, your task will be to bring the chair back to that position.

You do this by pressing the buttons on the arms of the chair. To move the chair to the right, press the right hand button, to move it to the left, press the left hand button. If you think you overshot the angle, press the other button to bring yourself back. When you think you have reproduced the angle, tell me so. Be sure to keep your arms on the arm rests throughout the test.

TASK 24: Rotary Pursuit

Apparatus



Description

The subject attempts to keep a prod stylus in contact with a small metallic target set in a rapidly revolving phonograph-type disc. The stylus has a spring-loaded hinged handle to prevent the S from pressing down hard on the target in order to maintain contact. The target is a 3/4 inch brass disk set in the turntable. Score is the total time-on-target during fifteen 20-second trials, and is recorded electrically.

Instructions

Your task will be to keep the end of this rod on the metal target as it goes around.

You will do best if you relax and use a smooth, free swinging motion of the arm and shoulder.

Your score will be the total amount of time you stay in actual contact with the target.

You will stand directly in front of the apparatus. Don't stand too close. Hold the handle lightly, and keep it level, allowing the tip of the stylus to rest on the disc.

Keep the rod level, because the end is flat and makes a better contact that way. Use your right or left hand, but use the same hand throughout the test.

Now place the stylus on the target in the correct manner. Keep your free hand at your side.

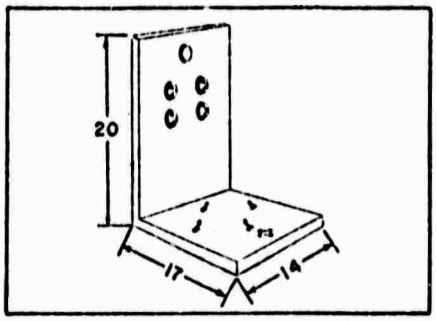
TASK 24 (Continued)

There will be a series of test periods and short rest intervals. There will be no practice. When the buzzer sounds, get on the target and try to stay on it. When the buzzer sounds again, the disc will stop. The disc starts as soon as the buzzer sounds. The rest intervals are very short.

Do you have any questions?

TASK 25: Discrimination Reaction Time

Apparatus



Description

The S manipulates one of four toggle switches as rapidly as possible in response to a series of visual patterns differing from one another with respect to the spatial arrangement of their component parts. Score is cumulated reaction time. Four trials of 20 reactions each.

Instructions

This is a test of how fast you can react to a signal. The signal will be a red light and a green light. This white light will come on at the same time as the signal lights, and your task will be to turn it out by snapping one of these switches. As I will explain later, the arrangement of these signal lights will indicate the correct switch.

Use your right or left hand, but use the same hand throughout the test. Always keep your hand in this position, with the end of your middle finger on the cross, and keep your other hand in your lap. When the lights come on, snap the correct switch as fast as you can, and come back to the resting position at the cross.

Place the end of your middle finger on the cross. There are only 4 signals, one for each of the four switches. Watch the lights while I explain them.

The red light is now below the green light. Snap the lower switch, the one nearest you. Note that only the white light goes out.

The red light is now above the green light. Snap the upper switch, the one farthest from you. Return your middle finger to the cross immediately.

The red light is now to the left of the green light. Snap the switch to the left. Do not hold the switch; snap it quickly.

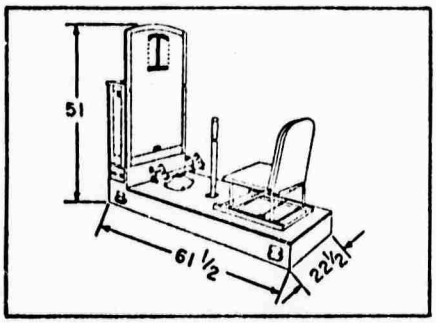
The red light is now to the right of the green light. Snap the right switch. Move fast.

All the signals have now been explained. Yoú can remember them by thinking: Red down from green, push down; Red up from green, push up; Red left of green, push left; Red right of green, push right. You see, it is the position of the red light with respect to the green light which indicates the correct switch. In the test, the clicking sound and the disappearance of the signal lights will warn you that the next set of lights is about to appear. Do you have any questions? We will now have a few practice trials. Ready ...

We are now ready to begin the test. The faster you turn out the white light, the better your score. Work as fast as you can. If you snap the wrong switch, keep on trying until the white light goes out. Always return your middle finger to the cross. There will be no talking during the test. Do you have any questions?

TASK 26: Complex Coordination

Apparatus



Description

The S is required to make complex motor adjustment of stick and pedal controls in response to successively presented patterns of visual signals.

A correct response (movement of stick and rudder controls to proper positions) is not accomplished until both the hands and feet have completed and maintained the appropriate adjustments. A new pattern appears as each correct response is completed. Score is the number of completed matchings. One 8-minute test period.

Instructions

Your task will be to line up a green light with each of the three red lights. Moving the stick from side to side moves the top green light. Moving the stick forward and backward moves the middle green light; and moving the rudder bar moves the bottom green light. Move the stick sideways to match the top green light with the top red light. Get it directly underneath. If it is off to one side like this it will not work. Then hold the stick in position to keep the top lights matched while you move it forward or backward to match the middle lights. Then hold the stick steady while you match the bottom lights with the rudder bar.

When you have matched all three lights, a new setting of red lights will appear. Go right ahead and match the new setting of red lights without bothering to come back to neutral.

TASK 26 (Continued)

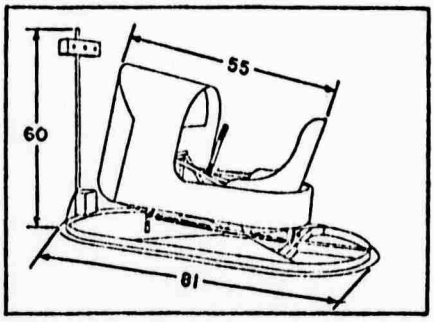
If you move any of the controls as far as it will go there will be no green light. You must ease back a bit to find the end green light.

When the test starts, you may use either your right or left hand on the stick, but use only one hand throughout the test. Keep your heels off the floor. Match as many settings of the lights as you can until they go out. If the red lights ever fail to come on, let me know immediately.

Your score will be the number of matchings you can make in the time allowed. Work as rapidly as you can. When the buzzer sounds, the test period begins. When all the lights go out again, the test will be over.

TASK 27: Rudder Control

Apparatus



Description

The S sits in a mock cockpit which his own weight throws off balance unless he applies proper correction by means of foot pedals. His task is to keep the cockpit lined up with one of three target lights. Score is total time on target. Three 30-sec. center target trials and three 112-sec. triple target trials.

Instructions

This test simulates the action of a plane on the ground. As you know, a plane on the ground is controlled by the rudder only, the stick has no effect. You will, however, keep both hands on the stick throughout the test.

As in a plane, if you push the right rudder forward, the nose turns to the right. As the left rudder is pushed, the nose turns to the left.

In the first test condition your task will be to keep the nose of the plane in line with the center light for as much of the test period as you can. Sight along this white sighting bar and line the apparatus up with the center light. The two outside lights will not be used in the first part of this test.

Place your feet on the pedals so that your instep fits on the pedal bar. Is there anyone here who cannot reach the pedals easily.

You will start from this off-center position with the nose to the left. When the center light comes on, the test period begins. Bring the nose in line with the light and keep it there the best you can.

TASK 27 (Continued)

When the light goes off, the test period ends. Relax until the center light comes on again.

This is your first test period. When the test period begins, push hard on the right rudder to bring the nose in line with the light; then equalize the controls and use a light quick touch to keep the nose in line with the light. Are there any questions? Begin when the light comes on.

In the second test condition the task is the same with one exception. The three lights will come on one at a time during the test period and will change in an irregular manner. Your task will be to keep the nose of the plane in line with the light which is on for as much of the test period as you can. When the light shifts, bring the nose in line with the new light as quickly as you can. Are there any questions? There will be a warning buzzer just before the beginning and at the end of each test period.

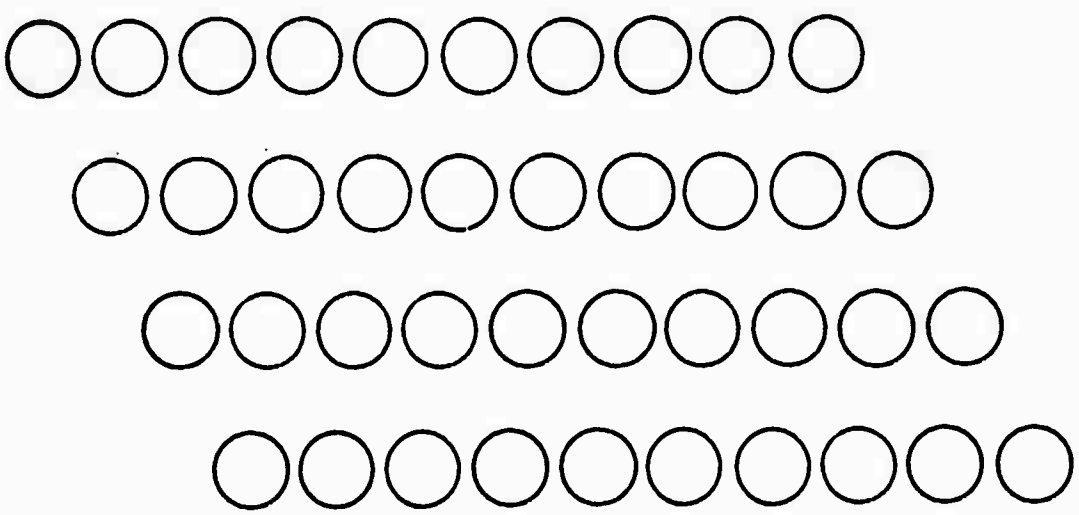
TASK 28: Medium Tapping

Description

The S is required to make three dots in each of a series of circles 3/8 inch in diameter, working as rapidly as possible. Two 15-sec. trials.

Instructions

This is the practice page for the next test. When the examiner says GO, but not before, you are to put three pencil dots in each circle just as fast as you can. Start at the left of each line and work to the right, as you do in writing. Count to yourself as you tap, and very fast, 1, 2, 3, - 1, 2, 3, etc. Try to make just three dots each time, but do not stop to correct. Speed is of more importance than accuracy. You do not need to strike hard nor raise your pencil high. Be sure to start and stop instantly. Do not start until the examiner says GO.

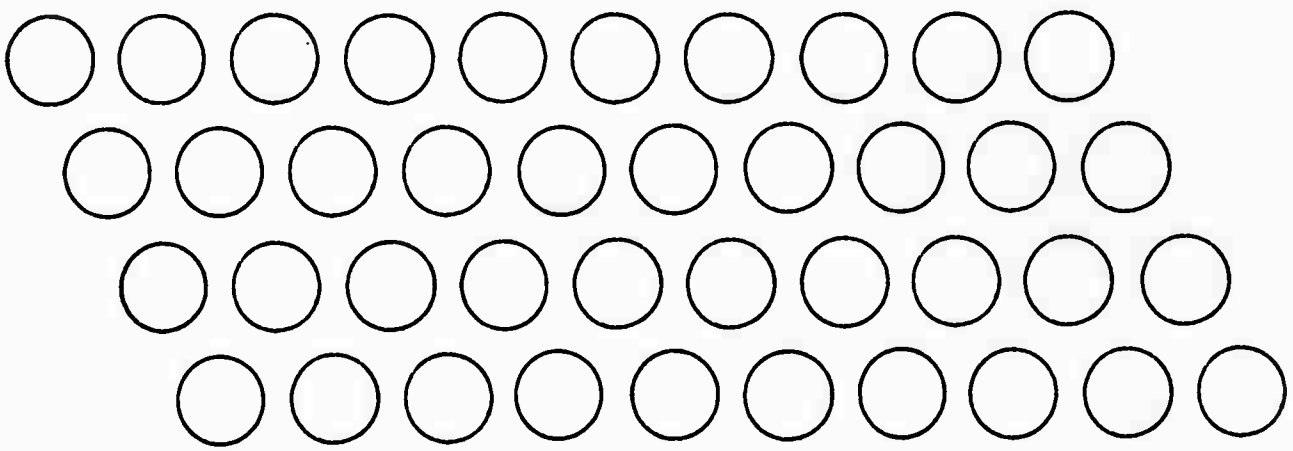


Description

The S is required to make three dots in each of a series of circles 1/2 inch in diameter, working as rapidly as possible. Two 15-sec. trials.

Instructions

When the examiner says BEGIN, put 3 dots in each circle beginning at the upper left and continuing across the page completing one line at a time. Work as quickly as possible.



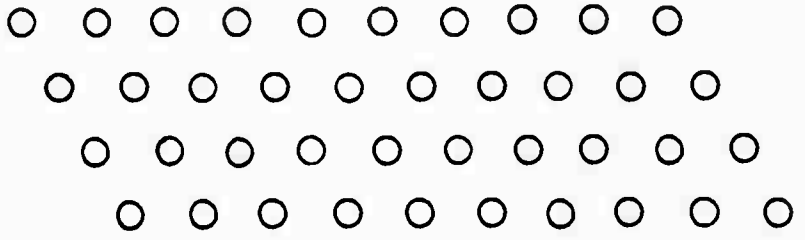
TASK 30: Aiming

Description

The S is required to make one dot in a series of very small circles (1/8 inch in diameter), working as fast and accurately as possible. Score is number of dots correctly placed. Two 30-sec. trials.

Instructions

In this test you will place only one dot in each circle, working as quickly as you can across one row and then across the next row. Remember, place only one dot in each circle. Dots must be clearly in the circle and only one dot will be counted for each circle. When I say BEGIN, work as quickly as you can.

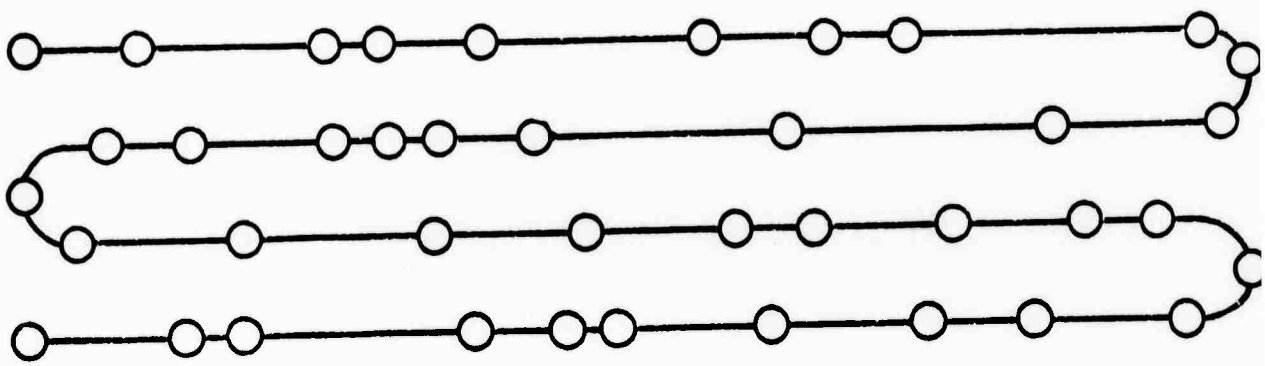


Description

The S is required to follow a pattern of small circles (3/16 inch in diameter) placing one dot in each circle around the pattern. Two 15-sec. trials.

Instructions

When the examiner says GO, but not before, you are to put one dot in each circle, as fast as you can. Follow the string. Dots must be clearly within the circles, and only one dot will be counted for any circle.



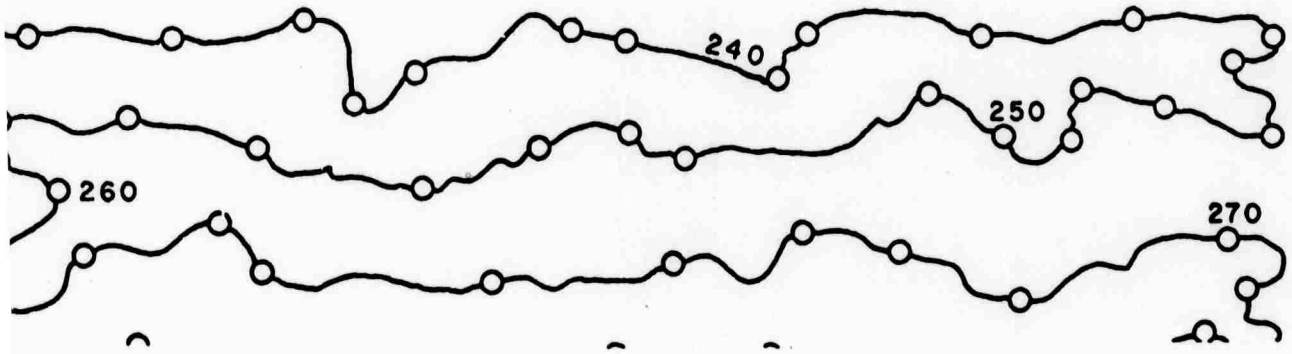
TASK 32: Pursuit Aiming II

Description

The S is required to follow a pattern of small circles (1/8 inch in diameter) placing one dot in each circle around the pattern. Two 60-sec. trials.

Instructions

When the examiner says BEGIN put a dot in each circle on the line. Begin at the upper right corner, and follow the line. When you come to the bottom of the first page continue on the top of the second page and work down the second page. Work as quickly as possible.



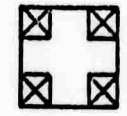
TASK 33: Square Marking

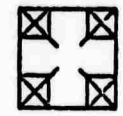
Description

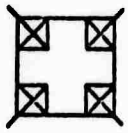
The S is required to place a series of x marks precisely inside a series of small (1/8 inch) squares. Score is the number of completed squares. Two 60-sec. trials.

Instructions

When the examiner says BEGIN, mark X's in the corners of the squares beginning at the upper left and continuing across the page. Each X must be completely within the small square. No part of it can be outside. Work as quickly as possible. Sample 1 below has been marked correctly. Samples 2 and 3 are not marked correctly.







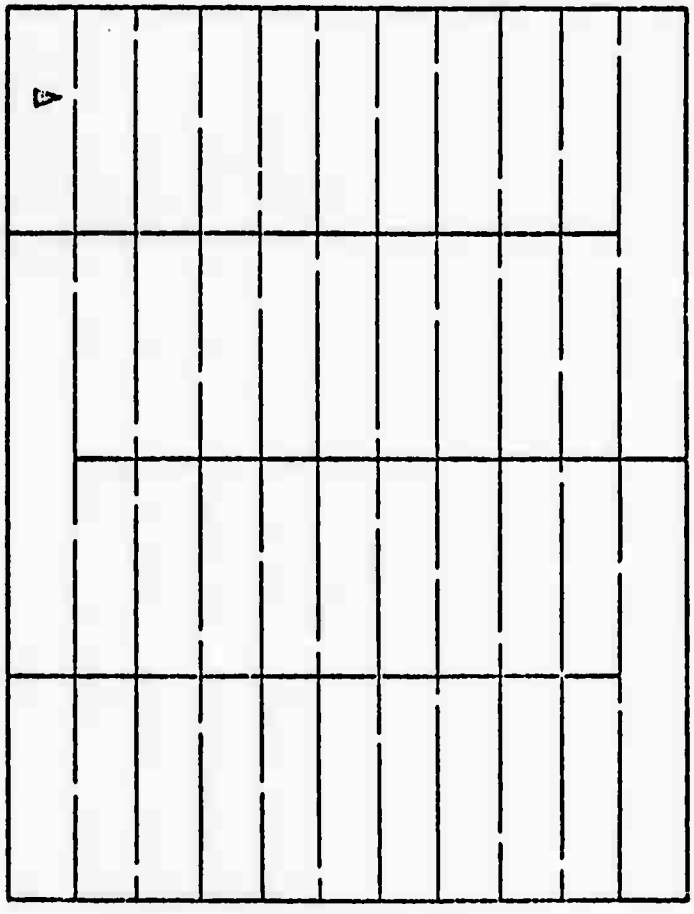
TASK 34: Tracing

Description

The S is required to trace through a series of small openings (1/16 inch) in a maze pattern. He must work as quickly as possible trying not to allow his pencil mark to touch any of the maze lines. Each touch is counted as an error. Score is number of openings negotiated minus the number of errors. One 25-sec. trial.

Instructions

Notice the little black triangle under the word START. Do not start until the examiner says GO. When the examiner says GO, but not before, you are to begin at the little triangle and draw a curved line through the small openings in the verticle lines without touching them. Draw first to the right and then back to the left in one continuous line.



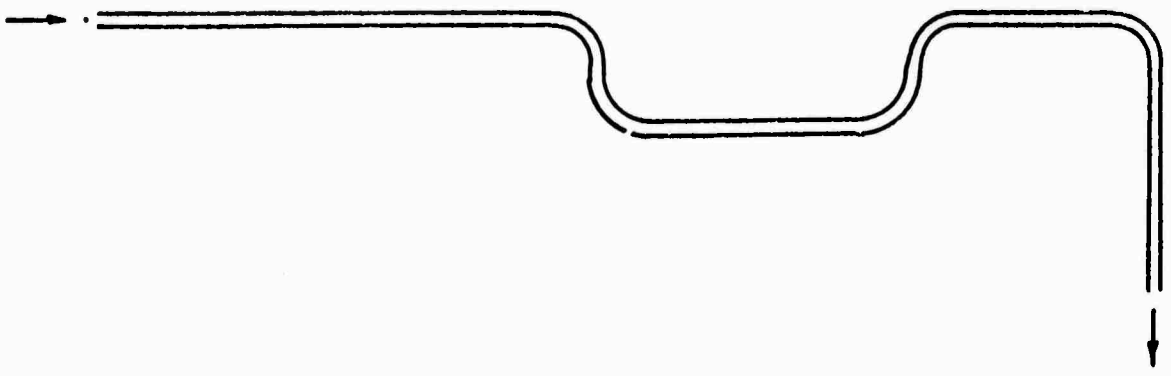
TASK 35: Steadiness

Description

The S must trace between a pair of narrowly separated lines (1/16 inch) which form a pattern. Score is the number of segments segotiated without touching the lines. Two trials, no time limit.

Instructions

In this test you are to trace between the lines of a pattern as steadily as you can. Start by placing your pencil on the dot at the beginning of the pattern. When told to begin, move your pencil steadily between the lines. Try as much as possible to stay within the lines without touching the sides of the pattern. Do not lift your pencil while you are tracing, but continue as best as you can to the end of the pattern. Below is a practice pattern. Place your pencil on the dot. Now begin tracing.



TASK 36: Discrimination Reaction Time - Printed

Description

This is a printed version of the Discrimination Reaction Time Test. The S is provided with a series of items. Each item represents a stimulus setting. There are four possible correct responses to each setting. The S goes from item to item as rapidly as possible checking the appropriate response. Score is the number of items completed minus the number of errors. Two 60-sec. trials.

Instructions

This is a test of speed of reaction to a signal. The signal will be an arrangement of a black and a white circle. There are only four arrangements of the circles, and four ways to mark your answer. Look at the sample problems below and the corresponding illustrations of the correct ways to mark your answer.

Sample Problems

A.

When the white circle is below the black circle, place a check on the bottom line.

B.

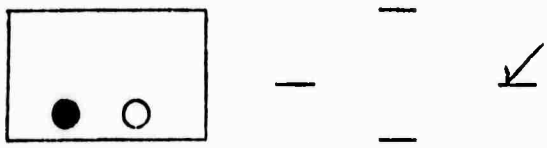
When the white circle is above the black circle, place a check on the upper line.

C.

When the white circle is to the left of the black circle, place a check on the line to the left.

TASK 36 (Continued)

D.



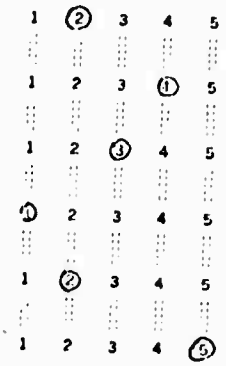
When the white circle is to the right of the black circle, place a check on the line to the right.

We are now ready to begin the test. Remember, this is a speed test. Work as fast as you can.

TASK 37: Marking Accuracy

Description

The S is given a standard IBM answer sheet in which one of the alternatives to each item has been overprinted with a small circle. The alternatives which are circled are randomly determined from item to item. The S's task is merely to mark the answer sheet as rapidly as possible under the indicated circles. Score is the number of items completed minus errors. Two 40-sec. trials.



Instructions

This is a test to see how fast you can mark an answer sheet.

You will notice that your answer sheet has a number of circled letters on it. These small circles indicate the spaces to be blackened for each item. Your job will be to mark this answer sheet in the spaces under each circle as rapidly as possible. It is important that only the correct spaces be blackened. Make a single heavy black mark under the correct spaces, going from item to item just as rapidly as you can. Are there any questions? There will be 2 trial periods.

You will begin when I say "Begin", and stop when I say "Stop."

READY! BEGIN

TASK 38: Log book accuracy

Description

The S is provided with a test booklet. Items in the booklet merely pair an alternative letter with each item number. The S must find the number on a separate IBM answer sheet and mark in the indicated space the appropriate letter for each item as rapidly as possible. Score is the number of correct items minus errors. Two 120-sec. trials.

Instructions

In the test booklet are listed item numbers followed by the answers A, B, C, D, or E to be marked. The item numbers are in random order rather than in sequence. Your task is to record in the space provided on the answer sheet the appropriate letter for each item. You should work as quickly and accurately as possible.

Test

Opposite each of the item numbers in the test booklet is a letter. Your only task is to blacken the space on your answer sheet which corresponds to the item number and letter in the booklet.

Look at the five sample items:

1. C.
4. A.
3. D.
2. E.
5. B.

If you were marking your answer sheet, you would blacken space C opposite item 1; space A opposite item 4; and so on.

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