USING COMPUTERIZED TESTS TO MEASURE NEW DIMENSIONS OF ABILITIES: AN EXPLORATORY STUDY

CHARLES H. CORY
Navy Personnel Research and Development Center

Because most of the research with computer-assisted test administration has been concerned with tailoring item difficulties to test takers, what appear to be important characteristics of computerized equipment for expanding dimensionality of measurement appear to have been largely ignored. Since paper-and-pencil tests are limited in terms of stimulus control and response mode, the near exclusive reliance on them for personnel selection has imposed restrictions on the types of abilities which can be measured. For example, using conventional paper-and-pencil tests, it is difficult if not impossible to present a moving stimulus, obtain measures of tracking performance, control item exposure time, record response latencies, or sequence items as a function of prior responses. Computer terminals of the type ordinarily used for programmed instruction do have these capacities.

The battery of tests developed for the present research has been especially designed to exploit the special capabilities of computer terminals for pictorial display and movement and has thus been designated the Graphic Information Processing (GRIP) series. A major interest of the research was in finding abilities which are important for on-job performance which computerized tests could measure accurately but paper-and-pencil tests could not.

As a starting point for the investigation, five traits of "real world" significance as defined by Mecham and McCormick (1969) were selected. They were Short Term Memory, Perceptual Speed, Perceptual Closure, Movement Detection, and Dealing with Concepts/Information. Empirical data on the relative importance of these attributes for work performance is available from Mecham and McCormick (1969). The study was designed to provide comparisons of computerized and paper-and-pencil tests designed to measure these attributes and to compare the computerized measures and the operational variables in terms of dimensionality and validity for job performance criteria.

The equipment used for the research consisted of the IBM 1500 system plus a cathode ray tube (CRT) display unit and a screen for film presentation linked on-line to an IBM 1130 computer. Subjects responded to visual stimuli presented on the CRT by touching a target with a light pen, or by entering a response into the typewriter keyboard. Programming was carried out in Coursewriter.

The GRIP Tests

The GRIP battery consisted of eight computer-administered tests, each designed to measure a major aspect of one or more of the five job elements.

Illustrative items from each of the GRIP tests are shown in the Appendix.

1. *Memory for Objects.* Frames showing line drawings of common objects with simple one word names were flashed on the screen at an average exposure time of about one-half second per object per frame. Number of objects per frame ranged from three to nine. After the exposure period, subjects typed in the names of all of the objects remembered.

2. *Memory for Words.* The test was identical in intention and arrangement to the Memory for Objects, but with words substituted for the pictures. Of course the object of this test was to compare the recall of words given with the recall of words generated by the candidates' recognition and labeling processes. Words were of two lengths: 3-letters and 5-letters.

3. *Visual Memory for Numbers Test.* This is a digit-span test using the same type of methodology as was used for the two preceding tests but having digits as stimuli. About 50 percent of the digits were presented sequentially and the other 50 percent were presented all at once, as a single stimulus.

4. *Comparing Figures.* The frames of this computerized measure of perceptual speed contain sets of squares or circles presented as rows, vertical columns, and right and left slant columns. Three to six stimulus pairs are shown on the screen at a time. Each stimulus has a crossbar, oriented either vertically or horizontally. Subjects are asked to record as true-false answers whether or not all crossbars of corresponding pairs in a set have the same orientations.

5. *Recognizing Objects.* For this computerized closure test partially blotted-out pictures of common objects are presented. The first presentation shows 10 percent of the area and more area is added in random increments of 10 per unit until 90 percent of the picture is exposed. Subjects enter the names of the stimuli on the keyboard.

6. *Memory for Patterns.* A test designed to measure movement detection abilities, in which patterns are formed by sequentially blinking dots. Subjects are asked to report whether or not two consecutive patterns are identical and for other items they are asked to reproduce given patterns on the CRT with a light pen.

7. *Twelve Questions.* A test which resembles the Twenty Questions game in that subjects are asked to guess the name of an object based on yes-no answers supplied by the computer to questions. It differs from Twenty Questions in that the questions are supplied in the test rather than being posed by the subject. The subject's objectives are to select those questions which provide the quickest identification of the object and to avoid questions which are redundant or useless. Scores are sums of correct responses weighted by number and characteristics of the clues received.

8. *Password.* A test which resembles the regular "Password" game in that sets of words are shown on the CRT which suggest a target word. Five separate words are shown as clues. After the first two clues and each succeeding one, the name of the object may be typed on the keyboard. Scores are sums of correct responses weighted by number of clues received.

9. *Latency and Accuracy Variables.* In addition to direct measures of the personal attributes, latency measures were computed for speed of response for the Memory for Words and the Comparing Figures tests and latency of Recognizing Objects responses (speed of closure). In addition a measure of the total extent to which the response patterns failed to duplicate the stimuli in Memory for Patterns, free response was created (PAT-ERR).

Paper-and-Pencil Experimental Tests, Biographical Variables, and Operational Tests

Together with the GRIP battery, eight paper-and-pencil tests largely drawn from the ETS Kit of Reference Tests of Cognitive Factors (French et al., 1963), and a motion picture test (Drift Direction by Gibson, 1947) composed the set of experimental tests. In addition, data for each man were obtained for two biographical variables and for the nine tests which are routinely administered and used for Navy personnel decisions.

Samples

The experimental battery was administered to students at the Navy Training Center, San Diego, during May and June of 1972. Subjects were chosen from personnel in the first two weeks of technical training for three ratings having widely varied duties. Also tested in order to increase the sample size were recruits in their final week of training who were school eligible but had not yet received post-recruit assignments.

Ten to eleven months subsequent to the testing, after the subjects had served on jobs in the Fleet for several months, supervisory ratings covering both global and job element aspects of on-job performance were collected by mailout questionnaire.

The questionnaire used was an adaptation of the Position Analysis Questionnaire, a broad-based empirically-derived instrument developed by E. J. McCormick and his associates which has been extensively used for job classification research (McCormick, Jeanneret, and Mecham, 1972). The adapted questionnaire was used to collect ratings on global performance qs well as perfomance on all of the 42 job elements which were judged by a panel of Chief Petty Officers to be relevant to the positions.

After a preliminary review of the questionnaire returns, the 22 job elements having the largest representation in the sample were selected for analysis. These 22 job elements together with the sample size for each rating for each job element are shown in Table 1. For instance, the first rating, Electrician's Mate, involved Manual Control-Non-precision Tools, Assembling-Disassembling, Hand-Arm Manipulation/Coordination, etc. In contrast the Personnelman rating required Using Written Materials, Compiling Data, Operating Keyboard Devices, Persuading/Influencing Others, etc.; and the Sonar Technician rating required Using Pictorial Materials, Using Visual Displays, Adjusting Machines/Equipment, etc. The last group consisted of personnel in undifferentiated ratings, largely apprenticeship ratings. Major aspects of the assignments of this group involved Using Spoken Verbal Communication, Manual Control Non-precision Tools, Attention to Details, Completing Work, Working with Distractions, etc.

For each rating separately, zero-order validities of the tests for supervisors' marks of the job elements were computed and comparisons were made to identify the predictability patterns of attributes for job elements and to compare the operational, experimental paper-and-pencil, and experimental computerized tests as measures of these job elements. Similar types of statistics were computed and comparisons carried out for the ratings of global job performance.

RESULTS

Most of the statistically significant zero-order validities of the operational variables were found for the 12 job elements which are shown in Table 2. The predictor variables on the left are the Armed Forces Qualification Test, GCT a test of vocabulary and verbal reasoning, ARI, a test of arithmetic reasoning, MECH, a test of basic mechanical knowledge and principles, CLER, perceptual speed, SONR and RADIO, memory for pitches and sound patterns, ETST, electrical knowledge and mathematics, SHOP, Tool Knowledge, and lastly years of education.

TABLE 1

Sample Sizes for the Twenty-Two Most Common Job Elements

Job Element	EM	PN	ST	UA
Using Written Materials		48	30	71
Using Pictorial Materials	20		32	
Using Visual Displays			35	66
Using Spoken Verbal Communication	20	52	36	92
Using Non-verbal Sounds			31	
Analyzing Information	20			
Compiling Data		49		
Manual Control-Non-precision Tools	27			80
Manual Control-Precision Tools	23			
Operating Keyboard Devices		53		
Adjusting Machines/Equipment	23		29	
Assembling-Disassembling	27			
Hand-Arm Manipulation/Coordination	22			
Hand-Ear Coordination			31	
Persuading Influencing Others		40		
Exchanging Routine Information		51		69
Unusually Good Precision			29	69
Attention to Details, Completing Work	25	51	36	102
Vigilance-Continually Changing Details	20			
Coping with Time Pressure	22	49		78
Working with Distractions		48		84
Keeping up to Date		52	30	86

TABLE 2

Significant Zero-Order Validities of the Operational Variables for Twelve Common Job Elements

Predictor Variable	Rating	Job Element: Written Materials	Pictorial Materials	Visual Display	Verbal Communication	Non-Precision Tools	Adjusting Equipment	Influencing Others	Routine Information	Good Precision	Attention to Details	Working with Distractions	Up-to-Date
AFQT	ST			-33*		--		--	--			--	
GCT	PN		--	--	50*	--	--			--			36*
	UA		--		22*		--	--	27*				
ARI	ST	49**				--		--	--			--	
	UA		--		24*		--	--	41*	27*	23*		
MECH	PN		--	--		--	--	55**		--	38*		
CLER	UA	25*	--		20*		--	--		29*	30**		26*
SONR	PN		--	--		--	--			--			37*
	UA	-26*	--				--	--					-26*
RADO	EM	--		--				--	--	--	-44*	--	--
	ST	36*	41*		33*	--		--	--		37*	--	39*
	UA		--		22*		--	--					
ETST	UA		--				--	--	28*				24*
SHOP	PN		--	--	45*	--	--	42*		--			
YRED	UA		--		21*	22*	--	--	34**	31**	26**		
		Cell Ns											
	EM		15		16	21	18				19		
	PN	26		29	27			20	28		29	27	31
	ST	29	30	33	34		27			27	34		28
	UA	69		66	90	79			67	67	100		84

Note. Decimal points were omitted from validity coefficients.

Coefficients significant at $p < .05$ and $p < .01$ have been identified by single and double asterisks, respectively.

A blank cell indicates nonsignificant validity.

A double hyphen (--) indicates missing data.

Only the statistically significant coefficients are shown. The level of significance is indicated by a single underline for the five percent level and double underlines for the one percent level. Blank cells indicate non-significant validities and double dashes indicated that the *N*s were too small for validity coefficients to be computed. Rows for individual ratings which did not have any statistically significant validities have been omitted.

Operational variables were generally not effective for predicting performance on job elements in the technical ratings, and where effective did not seem to be associated with underlying relationships or constructs. For instance, the writing abilities of ST's do not appear to be logically related to scores on ARI and RADIO, but they were significantly correlated with them. Similarly, the reasons for the significant relationships between RADIO and Pictorial Materials, SHOP and Verbal Communication abilities, ARI and Communicating Routine Information, MECH and Influencing Others, and CLER with writing and verbal communication skills were not clear. Yet all of these relationships were found.

On the other hand interpretation of the significant predictor-job element validities is much more logical and consistent for the experimental tests (Table 3).

TABLE 3

Significant Zero-Order Validities of the Experimental Variables for Twelve Common Job Elements

Predictor Variable	Rating	Job Element: Written Materials	Pictorial Materials	Visual Display	Verbal Communication	Non-Precision Tools	Adjusting Equipment	Influencing Others	Routine Information	Good Precision	Attention to Details	Working with Distractions	Up-to-Date
Obj. No.	EM	--		--				--	--	--	-38*	--	--
Mem. Obj.	EM	--		--			-53**	--	--	--		--	--
	UA		--			-24*	--	--				-24*	
Mem. Words	ST	42*				--		--	--			--	
	PN	29*	--	--		--	--			--			
Mem. for Nos. (V)	PN	33*	--	--	48**	--	--			--			33*
	ST	40*				--		--	--			--	
Mem. for Nos. (A)	PN	29*	--	--	42**	--	--			--			
	EM	--		--				--	--	--	-42*	--	--
Counting Numbers	UA		--				--	--			26**		
	ST					--		--	--			--	39*
Comp. Figs., Machine-paced	UA	25*	--		20*		--	--		29*	30**		26*
	PN		--	--		--	--			--			44**
Gest. Comp.	EM	--		--		-40*		--	--	--	-42*	--	--
Hidden Patterns	EM	--		--		-36*		--	--			--	--
	PN		--	--	30**	--	--	32**		--			34*
	ST		39*			--		--	--			--	35*
Rec. Objs.	ST	45*				--		--	--			--	
Mem. for Pats., Free Response	ST	40*				--		--	--			--	38*
	UA		--				--	--			24*		28**
	PN		--	--		--	--			--		36*	25*
Nonsense Syls.	EM	--		--				--	--	--	-38*	--	
Inference	PN	37*	--	--	42**	--	--	49**	37*	--			29*
Twelve Questions	PN	42**	--	--	44**	--	--	36*	55**	--		42**	31*
	ST					--		--	--			--	37*
Password	PN	33*	--	--	43*	--	--			--	30*		
	ST					--	46*	--	--			--	
WORD-LAT	EM	--		--			-41*	--	--	--		--	--
CLO-LAT	ST		-47**	-44**		--		--	--			--	-37*
PAT-ERR	UA		--				--	--			-21*		-23*
	PN		--	--		--	--			--		-37*	
FIG-LAT	PN		--	--		--	--	-36*		--			
	ST			34*		--		--	--			--	
	UA		--				--	--		31**			
Cell Ns													
	EM		20		20	27	23				25		
	PN	45			48			37	47		47	44	48
	ST	29	31	34	36		29			29	36		30
	UA	71		66	92	80			69	69	102	84	86

Note. Decimal points were omitted from the validity coefficients.

Coefficients significant at $p < .05$ and $p < .01$ have been identified by single and double asterisks, respectively.

A blank indicates nonsignificant validity.

A double hyphen (--) indicates missing data.

The first five tests are short term memory tests with the first test being the ETS Kit test of Associative Memory, the next three being computerized memory tests and the last an auditorily administered measure of digit span. Interestingly the memory tests show consistent negative correlations with job elements for Electrician's Mate and the Apprenticeship group and positive correlations for Sonar Technician and Personnelman. The correlations for PNs are for Writing and Verbal Communication Skills, two job elements for which it would be logical to expect positive correlations.

The next two tests, Counting Numbers and Comparing Figures, are respectively paper-and-pencil and computerized tests of perceptual speed. Both tests discriminate primarily for Personnelmen and the Apprenticeships ratings and the patterns of validities of the two tests were very similar.

The next three tests, together with CLO-LAT, measure perceptual closure. Gestalt Completion and Hidden Patterns were from the ETS battery, and Recognizing Objects and CLO-LAT were computerized measures. The tests have negative validities for Electrician's Mate and positive validities for Sonar Technician, with primarily visual types of elements being predicted for the latter rating.

The next test was separate parts of the computerized test designed to measure movement detection. It had significant validities for Sonar Technician and also had significant validities for Personnelmen and the Apprenticeship rating group.

Nonsense Syllogisms and Inference, measures of syllogistic reasoning from the ETS battery, and the next two tests, 12 Questions and Password, are computerized variables hypothesized to measure the same type of ability. For Personnelmen both Inference and 12 Questions were significantly related to job performance and the patterns of significant validities were very similar.

The four special variables at the bottom of Table 3 correlated with visual skills and with job elements involving accuracy and precision.

These relationships are summarized in Table 4 which shows the number of significant validities of the operational, experimental paper-and-pencil, and experimental computerized variables for the job elements in each rating in which they were present.

Major areas in which the computerized measures were useful predictors were Adjusting Equipment for Electrician's Mates, Writing and Working with Distractions for Personnelmen, and Visual Displays for Sonar Technicians. In addition computerized measures were useful supplemental predictors of communication and interpersonal relationships skills for Personnelmen. Thus, the computerized tests predicted job elements which would be expected to be central to global performance for the Personnelman and Sonar Technician ratings.

TABLE 4

Significant Zero-Order Validities of Operational and Experimental Variables for Twelve Common Job Elements

	EM			PN			ST			UA		
JOB ELEMENTS	Operating Variable	Experimental Paper-and-Pencil	Experimental Computerized	Operating Variable	Experimental Paper-and-Pencil	Experimental Computerized	Operating Variable	Experimental Paper-and-Pencil	Experimental Computerized	Operating Variable	Experimental Paper-and-Pencil	Experimental Computerized
Skill Writing				–	2	4	2	–	4	2	–	1
Pictorial Materials	–	–	–				1	1	1			
Visual Displays							1	–	2	–	–	–
Verbal Communication	–	–	–	2	3	3	1	–	–	5	–	1
Non-precision Tools	–	2	–							1	–	1
Adjusting Equipment	–	–	2				–	–	1			
Influencing Others				2	2	2						
Routine Information				–	1	1				4	–	–
Good Precision							–	–	–	3	–	2
Attention - Details	1	4	1	1	–	1	1	–	–	3	1	3
Work Distractions				–	–	3				–	–	1
Keep Up to Date				2	2	3	1	2	3	3	–	3

TABLE 5

Zero-Order Validities of Experimental Variables for Global Performance

Predictor	Validity EM (*N*=27)	PN (*N*=54)	ST (*N*=37)	UA (*N*=111)
Short Term Memory				
Object Number	−.26	.13	−.03	−.01
Memory for Objects	−.16	−.03	−.05	−.07
Memory for Words	−.33	.20	.13	.01
Memory for Numbers(V)	−.15	.20	.38*	−.01
Memory for Numbers(A)	−.15	.17	.22	.08
Perceptual Speed				
Counting Numbers	.03	.04	.42	.06
Comparing Figures, Machine-paced	.02	−.10	.07	−.06
Comparing Figures, Self-paced	.06	.07	.21	.08
Closure				
Gestalt Completion	−.28	−.26 *	.28	.06
Concealed Words	−.37 *	−.14	.13	−.10
Hidden Patterns	−.04	.23	.33 *	.11
Recognizing Objects	−.11	−.06	.25	−.05
Movement Detection				
Drift Direction	−.29	.07	.02	.06
Memory for Patterns, True-false	.15	−.07	.42	.07
Memory for Patterns, Free Response	.19	.21	.23	.19
Dealing with Concepts/Information				
Nonsense Syllogisms	−.30	.01	.30	−.06
Inference	.18	.19	.00	.13
Twelve Questions	−.20	.28	.21	.11
Password	.08	.13	.33	.04
Special Variables				
WORD-LAT	−.24	−.06	−.05	−.11
CLO-LAT	.05	.02	−.24	−.11
FIG-LAT	−.04	.00	.02	.04
PAT-ERR	−.24	−.17	−.26	−.13

*Significant at $p < .05$.

Zero-order validities of the experimental variables for the global rating of job performance are shown in Table 5. Nine of the 92 validity coefficients (10 percent) were statistically significant. Of the nine, five were for computerized tests. Most of the significant validities were for Sonar Technicians. In comparison, five of 35 validities of the operational tests were statistically significant (Table 6), of which three were for the UA group.

Thus, variables in the operational battery were best for predicting global performance in apprenticeship ratings whereas those in the experimental battery were more useful for predicting performance in technical ratings, and were particularly good for predicting the performance of Sonar Technicians. Personal attributes having the highest numbers of significant validities were Movement Detection and Dealing with Concepts/Information.

TABLE 6

Zero-Order Validities of Operational Variables for Global Performance

Predictor	Rating Group			
	EM	PN	ST	UA
	(N=21)	(N=31)[a]	(N=35)	(N=109)[a]
AFQT	−.09	.15	−.12	.13
GCT	.01	.24	.11	.07
ARI	−.20	.10	.38*	.25**
MECH	.04	.23	−.04	.12
CLER	.21	−.15	.11	.19*
SONR	−.08	.15	−.08	−.03
RADO	−.06	.11	.15	.15
ETST	.16	.31	−.09	.33**
SHOP	.20	.38*	−.21	.17
YRBI	−.12	.06	.01	−.11
YRED	.11	.05	−.02	.22*

[a]Complete data were not available for some of the tests.
*Significant at $p < .05$.
**Significant at $p < .01$.

TABLE 7

Optimal Predictive Composites for Global Performance of Electrician's Mates

Predictor Set	R		Predictor	Beta Weight in Final Composite	N
	Weight Determination	Expected Cross Validation			
Operational Classification Test Scores	.21	.00	CLER		27
Complete Set of Experimental and Operational Variables	.37	.00	Concealed Word	−.40	27
	.49	.20	CLER	.39	
	.58	.28	Drift Direction	−.28	
	.65	.34	PAT-ERR	−.50	
	.71	.40	Memory for Words	−.40	
	.78	.53	YrBi	−.36	

Multiple regression statistics for optimal sets of the operational and experimental variables for Electrician's Mate are shown in Table 7.

The first super row shows statistics for the optimal predictive composite for the eleven operational scores and the same type of statistics for the complete battery of operational and experimental variables are shown in the second super row. The second column contains the shrunken validity coefficient for each predictor selection step. Addition of the experimental tests to the battery increased the expected cross validity substantially although the sample size is so small that these figures should be interpreted with caution. The negative beta weights for PAT-ERR and YrBi are artifacts of the direction of scaling for those variables.

The same type of finding was characteristic of the predictive composite for Personnelman (Table 8). Again the negative validity of WORD-LAT was an artifact of direction of scaling.

For Sonar Technicians (Table 9) inclusion of the experimental tests in the battery added 38 points to the shrunken multiple correlation. All of the variables selected for the complete set were measures of perceptual types of abilities.

On the other hand, the experimental variables added almost no increment to the expected cross validation for the Apprenticeship group (Table 10).

The usefulness of this type of expansion of coverage of the battery may be illustrated by reference to the abilities

TABLE 8

Optimal Predictive Composites for Global Performance of Personnelmen

Predictor Set	R: Weight Determination	R: Expected Cross Validation	Predictor	Beta Weight in Final Composite	*N*
Operational Classification Test Scores	.38	.12	SHOP	.38	30
	.38	.12	SHOP	.22	
Complete Set of	.47	.20	Gestalt Completion	−1.19	
Experimental and	.64	.46	GCT	1.40	
Operational	.71	.52	FIG-LAT	.69	30
Variables	.80	.65	WORD-LAT	−.40	
	.86	.74	Mem. for Patterns, t.f.	.37	

TABLE 9

Optimal Predictive Composites for Global Performance of Sonar Technicians

Predictor Set	R: Weight Determination	R: Expected Cross Validation	Predictor	Beta Weight in Final Composite	*N*
Operational Classification Test Scores	.38	.22	ARI	.38	37
Complete Set of	.42	.28	Counting Nos.	.33	
Experimental and	.54	.40	Mem. for Patterns, t.f.	.32	
Operational	.61	.46	Nonsense Syls.	.29	37
Variables	.66	.50	Recog. Objs.	.33	
	.73	.58	Gestalt Completion	.32	

TABLE 10

Optimal Predictive Composites for Global Performance of the Apprenticeship Group

Predictor Set	R: Weight Determination	R: Expected Cross Validation	Predictor	Beta Weight in Final Composite	*N*
Operational Classification Test Scores	.33	.28	ETST	.33	111
Complete Set of	.33	.28	ETST	.33	
Experimental and	.37	.29	CLER	.21	111
Operational Variables	.41	.32	Concealed Word	−.19	

which are being measured by the elements in each of the four predictor composites selected. Thus, for EM to the Perceptual Speed measure in the operational battery were added Closure, Movement Detection, Memory, and Accuracy of Spatial Perception from the experimental battery. For Personnelman, to the Technical Knowledge component, which provided the primary predictiveness in the operational battery, were added measures of Closure, Speed of Response and Memory from the experimental battery. For Sonar Technician, to the general mental ability component in the operational battery were added measures for the Movement Detection and Closure components from the experimental battery. And for the UA group to the measures of Technical Knowledge and Perceptual Speed from the operational battery was added a measure of Closure from the experimental battery. With the exception of the Closure measures, some of which were paper-and-pencil, most distinctive predictive validities from the experimental battery were supplied by computer-administered tests.

DISCUSSION AND CONCLUSIONS

It is clear that the experimental battery represents an increase in the breadth of abilities covered beyond those in the operational Navy battery, a considerable amount of which is attributable to the GRIP tests. Computer tests apparently provided measures of several attributes which were different from those measured by paper-and-pencil tests. Furthermore, the measurement expansions of the experimental battery served to supplement the measures of the operational battery to produce substantial increases in global validities.

The unique measurement characteristics of the GRIP tests appear to be as follows:

1. Computer administration of tests of short term recall using a variety of stimuli is feasible, and appears to offer advantages in ease of data collection and processing over paper-and-pencil tests measuring the same attributes. Furthermore, use of computerized tests to eliminate the expensive and time consuming hand scoring required by paper-and-pencil tests of short term memory would make it feasible to routinely measure these skills during personnel classification testing. Computerized measures of this attribute were found to have significant positive validities for several job elements, particularly for those dealing with communication. It is probable that use of the tests for other occupations would identify additional relationships which are useful for personnel classification.

2. Computerized administration of perceptual speed, as carried out in the GRIP battery, was only marginally different from paper-and-pencil measures of perceptual speed. Since these measures did not offer any substantial improvements in validities over paper-and-pencil measures, the initial judgment on their usefulness would be negative.

3. Further research will be required to clarify the relationships between computerized and paper-and-pencil measures of Closure. Hidden Patterns, the best of the paper-and-pencil tests, had significant validities for Electrician's Mates, Personnelmen, and Sonar Technicians. The pattern of validities of Hidden Patterns for Sonar Technicians was duplicated by CLO-LAT, a measure which can be administered and scored automatically.

4. The two experimental tests designed to measure Movement Detection were not closely related to one another and therefore did not provide evidence of a Movement Detection factor. Instead these tests loaded on memory factors, Perceptual Speed, and perceptual Closure. On the other hand, of the measures, Memory for Patterns proved to be very useful particularly as a predictor for both specific and generalized performance of Sonar Technicians. For the Electrician's Mate and Personnelman ratings it proved to be useful at a somewhat lower level.

5. Facility in Sequential Reasoning was apparently an ability which was uniquely measurable by computer-administered tests. These tests demonstrated widespread and generalized validity for Personnelman and incremented the predictability of communication and interpersonal relations skills over that available from paper-and-pencil tests.

It is believed that the initial results with this technique are promising and that further development along these lines is warranted, particularly for jobs which require attention to scopes. Consequently, research to be carried out during Fiscal Year 1976 will be concerned with refining measures of Movement Detection, Sequential Reasoning Perceptual Closure, response latencies, and accuracy of spatial perception, together with the construction of tests for other abilities which appear to be potentially useful for personnel selection. Also, we hope to convert one or more of the tests to a branching mode designed to tailor item difficulties to candidates.

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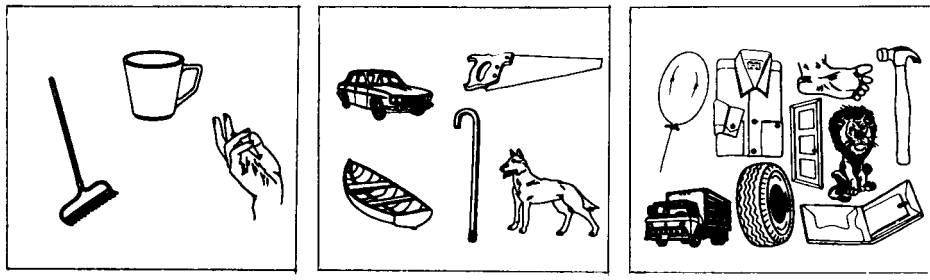
APPENDIX

ILLUSTRATIVE ITEMS FROM THE EIGHT COMPUTERIZED TESTS

1. MEMORY FOR OBJECTS



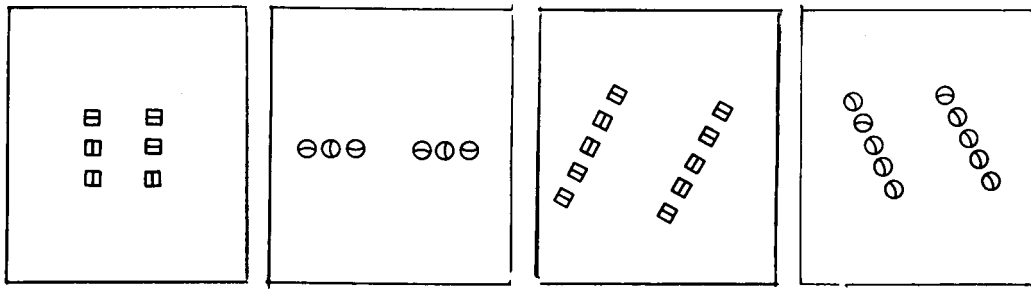
2. MEMORY FOR WORDS

3. VISUAL MEMORY FOR NUMBERS TEST

2 5 1 6*

124956387*

4. COMPARING FIGURES

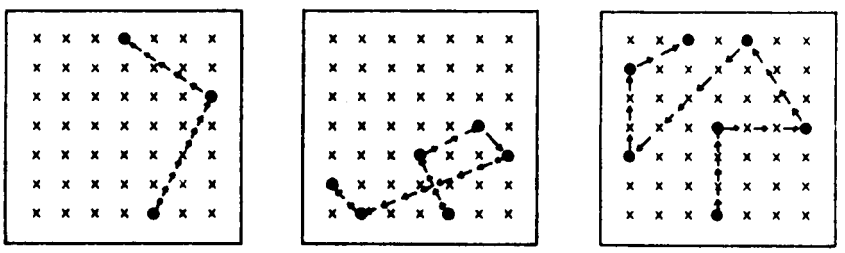


5. RECOGNIZING OBJECTS

90% 80% 60%

90% 80% 60%

6. MEMORY FOR PATTERNS



7. COMPUTERIZED 12 QUESTIONS

Mineral
Frequently larger than a glove

1. Is it often used as clothing?
2. Is it made of a soft material?
3. Is it often used at meals?
4. Do people often wear it?
5. Does it have moving parts?
6. Does it have a hard surface?
7. Is it always found on an auto?
8. Is it made at least partly of glass?
9. Does it have more than one use?
10. Does it use electricity?
11. Is it sometimes used by magicians?
12. Do men and women use it equally often?
13. Is it often used before a person goes out?
14. Can one use it with his eyes closed?
15. Must one touch it to use it?
16. Does it appear dark in the light?
17. Can it be used to send messages?
18. Can it improve one's appearance?

(Mirror)

8. COMPUTERIZED PASSWORD

Metal Finger	Circle	Shiny	Wedding	(Ring)
Soaring Emblem	Feathers	Large	Bald	(Eagle)