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ABSTRACT

This paper is based on data from Work Unit UTILITY research on job performance of men at different ability levels. The paper deals with data testing performance in four jobs: Armor Crewman, Vehicle Repairman, Supply Specialist, and Cook, of various Armed Forces Qualification Test (AFQT) levels over specified periods of time. (Author)

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Performance in Four Jobs: The Role of Mental Ability and Experience

by

Robert Vineberg and Elaine N. Taylor

Symposium Presentation at the
American Psychological Association
Convention
Miami Beach, Florida September 1970

HumRRO

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Prefatory Note

This paper was presented at the American Psychological Association Convention in Miami Beach, Florida, September 1970, as part of a symposium entitled, "The Implications of Aptitude Level and Instructional System for Skill Acquisition and Job Performance." The research reported in this paper was performed at HumRRO Division No. 3, Presidio of Monterey, California, under Department of the Army contract with the Human Resources Research Organization as part of Work Unit UTILITY, Study of Soldiers in Lower Mental Categories: Job Performance and the Identification of Potentially Successful and Potentially Unsuccessful Men.

PERFORMANCE IN FOUR JOBS: THE ROLE OF MENTAL ABILITY AND EXPERIENCE

Robert Vineberg and Elaine N. Taylor

The problem of the lower aptitude man in the military, what he can do and what he can't do, is a perennial one. While experience has provided ample evidence that many men with low aptitude test scores can perform effectively, there is no systematic information about how well they really do. The data used are part of the HumRRO Research done under Work Unit UTILITY to provide such information. The research was designed to compare the job performance of men at different ability levels and to map the manner in which their performance changes as a function of the length of time they have been in their jobs. Since there is evidence that many low aptitude men do perform effectively, the research is also aimed at identifying those personal and background characteristics that might distinguish more effective marginal individuals. This paper, however, will be concerned with data bearing on only the first objective—mapping of performance as a function of the Armed Forces Qualification Test (AFQT) grouping and job experience.

The jobs we studied were Armor Crewman, Vehicle Repairman, Supply Specialist, and Cook. The Army jobs chosen were highly populated and with numbers of low aptitude men. These particular jobs were also selected because they covered a fairly broad range of job types and task complexity and because, with the exception of the Armor Crewman, each had a civilian counterpart.

The Armor Crewman job may be considered machine-ascendant in that it principally consists of sequences of interaction between a man, a tank, and its weapon systems, with most tasks being largely procedural. The Repairman job is a maintenance job that requires diagnostic and interpretive skills. The Supply Specialist job is clerical, calling primarily for the coordination and recording of information. The Cook job calls for preparation of food in accordance with a master menu and detailed recipes. Recognition of standards and precision in meeting them are primary characteristics of this job.

Job incumbents were tested in combat divisions in the United States and in Germany. Within each division pairs of men were selected for testing; one man with an AFQT or percentile score between 1 and 30 and one man with a score between 31 and 99. Pair members were carefully matched for the amount of time they had been in their jobs.[1] Particular care was taken to ensure that all men in the sample were working on a continuous daily basis in their jobs. A total of approximately 390 men or 195 pairs were tested in each job.

We measured performance using job sample tests, conventional multiple choice knowledge tests, and supervisor ratings. As is frequently the case, supervisor ratings failed to be discriminating enough to warrant further discussion. Our primary criteria were the job sample tests. We believe ours is the only study that has undertaken such extensive and direct measurement of performance. Each individually administered job sample test took from 3½ to 5 hours, depending on the job.

[1] In each job some men were studied who possessed up to 20 years of job experience.

Each job sample test was comprised of a number of subtests. To make testing realistic and to simulate job conditions with as much fidelity as possible, each subtest consisted of the performance of a single entire task with a natural beginning and ending. Tasks were composed of a series of actions or steps that would ordinarily be performed as part of a single operation in the performance of a job.

Subtest tasks or problems were introduced to subjects just as they might ordinarily encounter them. For example, one of the Repairman tasks involved the diagnosis and correction of a leaking oil seal in a fan shaft of a tank. The tank was prepared so that the oil seals leaked and the subject was told that oil was being thrown out of the tank's grill doors. The Repairman was to locate the source of the oil leak and repair the malfunction. Figure 1 shows the Repairman working on the initial steps.

General Vehicle Repairman's Test--Unbolting Fan Assembly

Figure 1

In this problem there were 19 necessary steps. Subjects earned a point for the correct performance of each step. This scoring procedure was used throughout the testing. The 13 subtests administered to Repairmen are shown in Figure 2 as an example of the job sample instruments used in all four job sample tests.

Figures 3-6 show the performance of men in different AFQT groups in the four jobs. Performance is plotted at 1-9 months on the job, 10-24 months, 25-60 months, and more than 60 months. Figure 3 shows results for Armor Crewman.

First, scores for each AFQT level go up with time in the job. While performance increases in each AFQT group with time, the groups maintain their positions relative to each other through the 25 to 60 month period on the job. It is not until men have been in their jobs for more than five years that we begin to see some evidence of convergence of the different groups. At this point men are averaging about 80% on the test which is a rise of about 30% from the first months on the job.

The Cook rate of growth is gradual (see Figure 4). Performance appears to start at a relatively higher level, probably because job procedures are described in cookbooks which were used during testing.

Repairman's Test

SUBTEST	NUMBER OF STEPS
SHIFT LINKAGE ADJUSTMENT, M60A1 TANK	11
TRANSMISSION SERVO BAND ADJUSTMENT, M60A1 TANK	13
VOLTAGE REGULATOR ADJUSTING RHEOSTAT ADJUSTMENT, M60A1 TANK	17
HYDRAULIC BRAKE PEDAL ADJUSTMENT, M60A1 TANK	11
OIL SEAL MALFUNCTION IN COOLING FAN VERTICAL DRIVE SHAFT, DETECTION AND REPLACEMENT, M60A1 TANK	19
IGNITION MALFUNCTION, FAULTY SPARK PLUG, DETECTION, M151 JEEP	9
IGNITION TIMING, CHECK AND ADJUSTMENT, M151 JEEP	19
CYLINDER COMPRESSION CHECK, M151 JEEP	13
BATTERY HYDROMETER TEST, M151 JEEP	11
BATTERY CONDITION TEST, M151 JEEP	13
WHEELBEARING, MALFUNCTION, DETECTION AND ADJUSTMENT, M151 JEEP	13
FUEL PUMP PRESSURE CHECK, M35A1/A2, M49C TRUCK	10
BLEEDING SERVICE BRAKE SYSTEM, M35A1/A2, M49C TRUCK	17
	176

Figure 2

Performance Test Score by AFQT and Months on Job: Armor Crewman

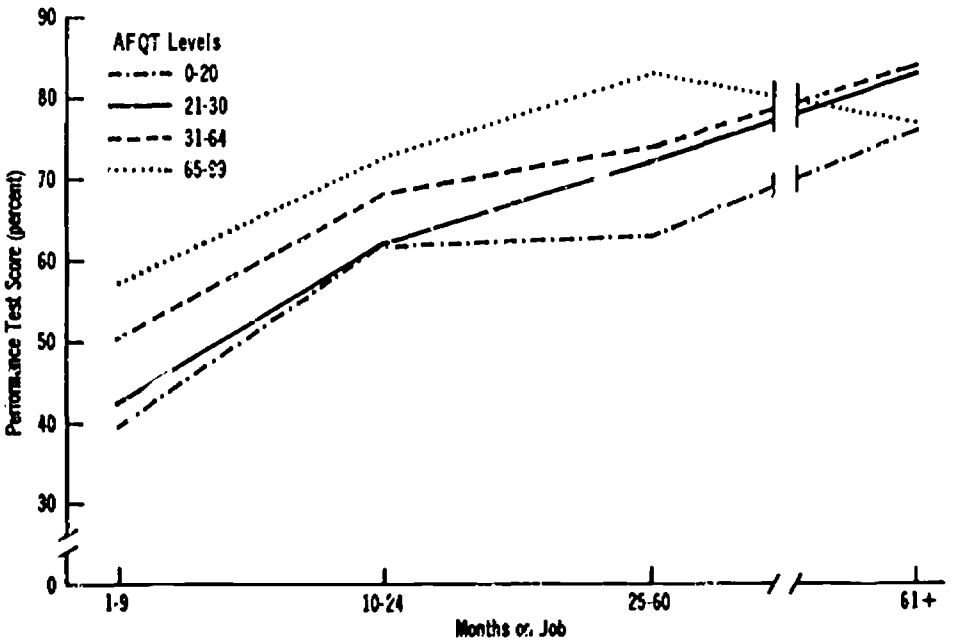

Figure 3

Performance Test Score by AFQT and Months on Job: Cook

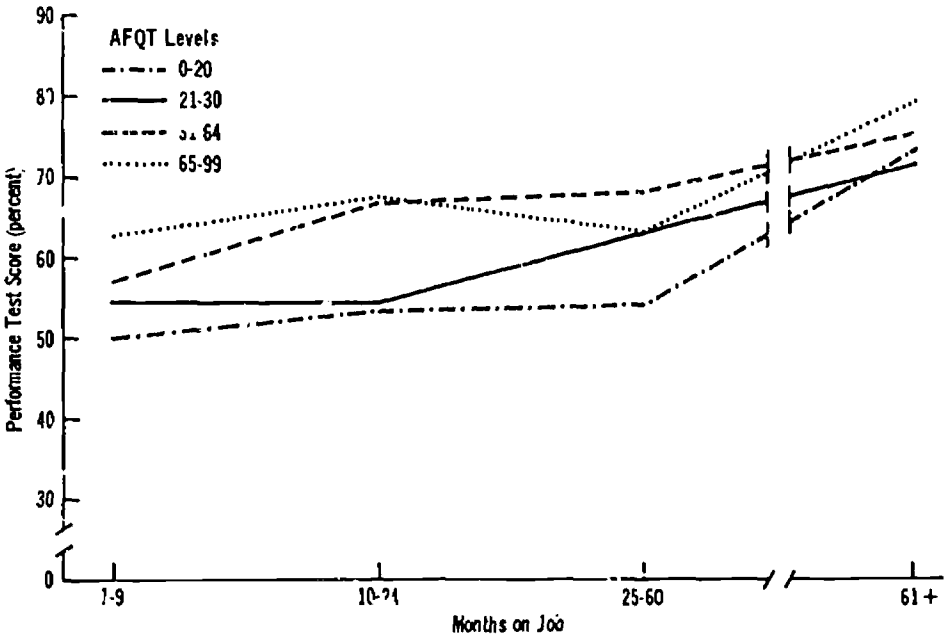

Figure 4

The results for the Repairman job in Figure 5 show growth as in the other jobs and fairly clear convergence after five years.

Finally, the Supply Specialist job shows generally the same trends. Here the upper three AFQT groups converge at five years but with the lowest group still behind.

The general pattern of development is pretty much the same overall. During the first nine months on the job men get about half the items on the test. After five years on the job growth occurs at all AFQT levels to a point at which men are getting about three-fourths of the test items and where there is some evidence of convergence.

Convergence is seen most clearly by focusing on the highest and lowest aptitude groups.

As seen in Table 1, the average difference between the very highest and lowest AFQT groups during the first nine months on the job is about 16%. Beyond five years on the job this difference decreased to about 5%. The lowest AFQT group has gained an average of 28% whereas the highest AFQT group, who of course perform better initially, gained about 16%.

Two different analyses of covariance were run to test the effects of AFQT and job experience. In one, we compared 0-20, 21-30, and 31-99 AFQT groups and partialled out time on the job and age. In the other, we compared men with 1-9, 10-24, and 25 months on the job and partialled out AFQT and education.

In all jobs, overall F tests for AFQT differences were significant and individual comparisons between the three AFQT groups were also significant.

For time on the job all Fs were significant, and out of 12 comparisons between pairs of means, 11 were significant.

Performance Test Score by AFQT and Months on Job: Repairman

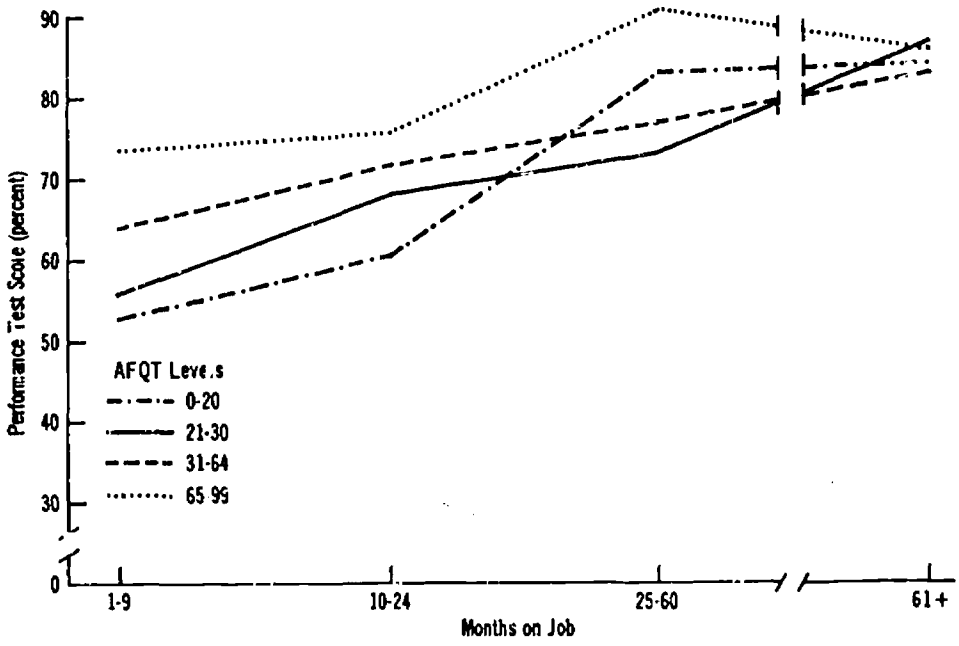

Figure 5

Table 1

Performance Test Score Range of Lowest and Highest AFQT Groups

(at 1-9 and 61+ Months-on-Job Experience)

	Months on Job			
	1-9		61+	
	AFQT 0-20 65-99	Difference	AFQT 0-20 65-99	Difference
Armor Crewmen	39-57	18	76-81	5
Cooks	50-62	12	73-79	6
Repairmen	53-74	21	84-86	2
Supply Specialists	50-63	13	69-76	7
	Mean Difference = 16%		Mean Difference = 5%	

Performance Test Score by AFQT and Months on Job: Supply Specialist

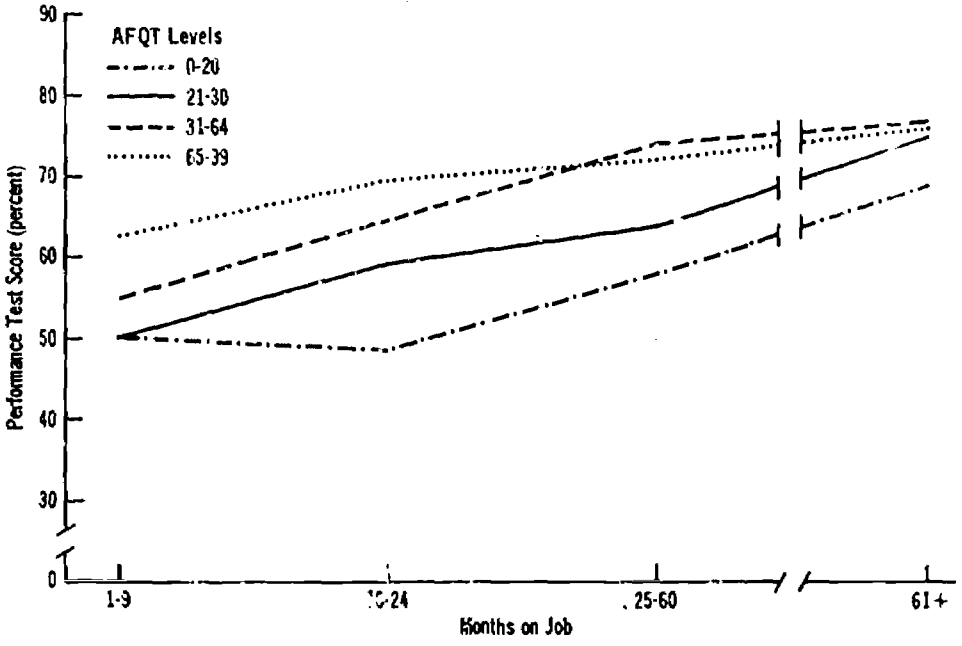

Figure 6

Although the amount of difference between AFQT or job experience groupings obviously depends on the particular groups selected for comparison, larger differences appear across the job experience dimension than across the AFQT dimension. Correlations also show a higher relationship between job experience and performance than between aptitude and performance. The average correlation between job experience and performance, with aptitude partialled out, was .60. The correlation between aptitude and performance, with job experience partialled out, was .35.

While the graphs using means show clear separation between AFQT groupings out to at least five years, a great deal of overlap exists across AFQT groups. An alternate method of presenting data is to group subjects according to their position on the job sample distribution. In Figure 7 the percentages of men in the different AFQT groupings falling in the lowest, two middle, and highest quarters of the Job Sample distribution are presented. The figure is drawn for men with 1-18 months of job experience for all MOSs combined.

Figure 7 reflects the general relationship between AFQT and job performance. Thus it is seen that there is a greater probability that men at the lower end of the AFQT distribution will perform in the lowest quarter. This is mirrored at the high end of the distribution in which men are more likely to score in the highest quarter. The critical observation is, however, that a substantial proportion of men at all AFQT levels fall into each quarter of the job sample distribution. For example, 33% of the 0-20 AFQT group score in the upper half of the distribution whereas 25% of the 65-99 AFQT group score in the lower half of the distribution. In the first 18 months, the similarity of performance of the High Category IVs and Category IIIs is striking. A little less than half (44%) of the High Category IV group scored above the median, whereas a little more

Distribution of AFQT Groups With 1-18 MOJ on Job Sample Tests

(Four MOSs Combined)

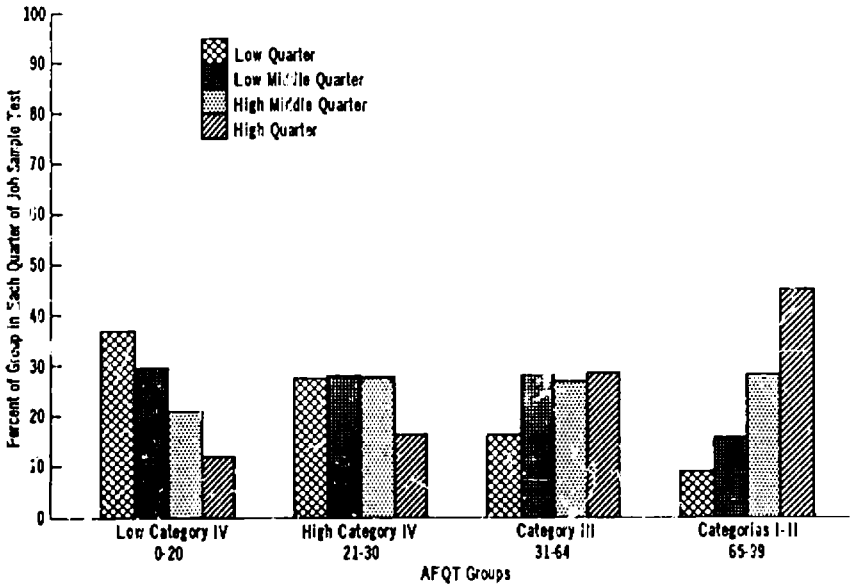

Figure 7

Distribution of AFQT Groups With 19-30 MOJ on Job Sample Tests

(Four MOSs Combined—in Relation to Quarters of 1-18 MOJ Subsample)

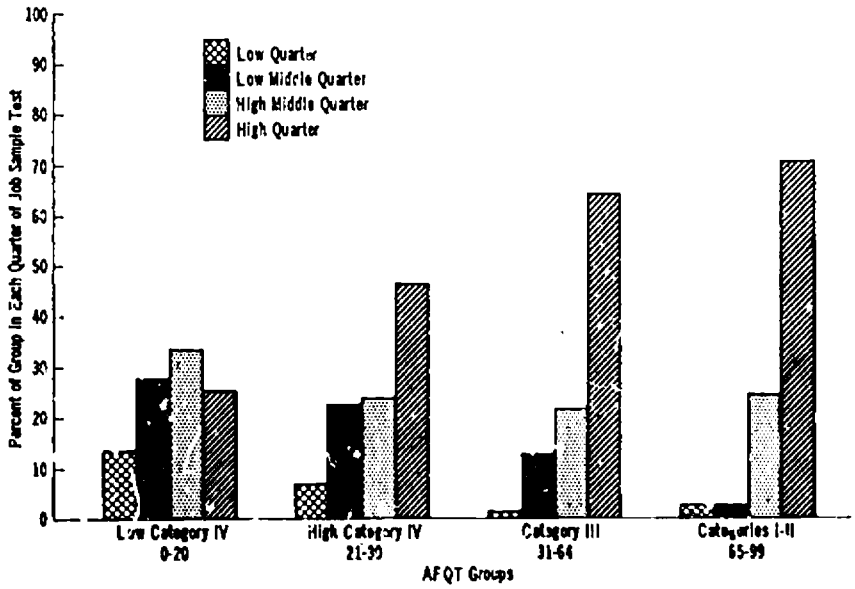

Figure 8

Distribution of AFQT Groups With 31+ MOJ on Job Sample Tests

(Four MOSs Combined—in Relation to Quarters of 1-18 MOJ Subsample)

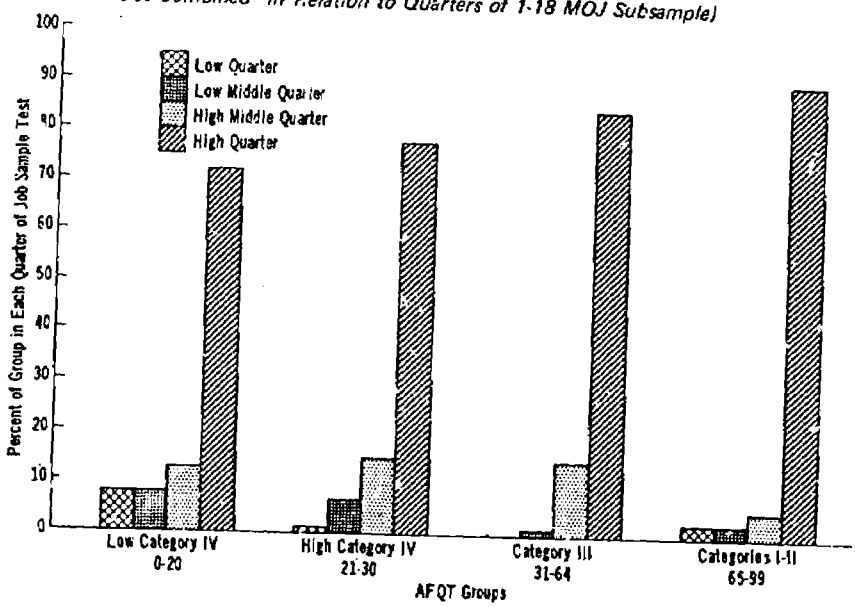

Figure 9

Job Knowledge Test Score by AFQT and Months on Job: Armor Crewman

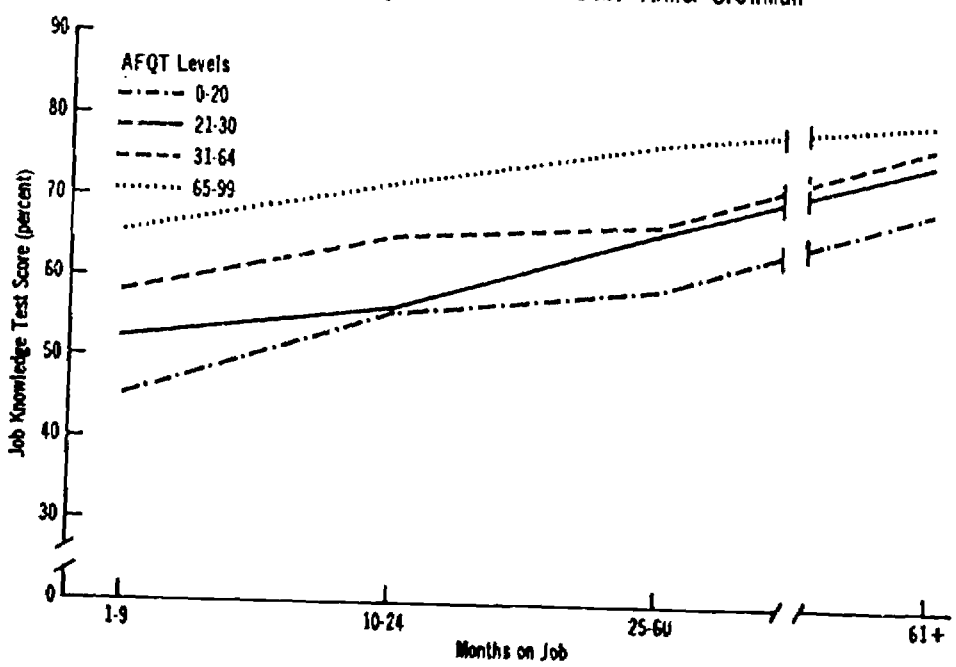

Figure 10

than half (56%) of the Category III group scored above the median. (The latter group has been historically acceptable for service.)

Men with between one and 18 months of job experience made up 67% of the UTILITY sample in the four MOSs reported on. The Army in general is heavily weighted with men in approximately the first two years of a first tour. Since, at any given time, most men working in an MOS fall within the first year and a half of job experience, performance in this time segment approximates modal performance in the Army. The data for men with longer job experience have been sorted into the quarters used for the data of the 1-18 month group to compare their performance. See Figures 8 and 9.

The implications to be drawn from these figures are that with time, an increasing proportion of men at all AFQT levels appear in the upper ranges of the performance distribution. Thus, among men with 19-30 months of job experience, 59% of the Low Category IV group fall in the upper half of the distribution. In the 30+ months group, 85% of the Low Category IV group fall in this upper half.

In addition to the performance tests, we administered more conventional multiple choice job knowledge tests. In Figures 10-13 test scores are plotted for the same AFQT groups and job experience intervals that were used in the earlier graphs.

The results for Armor Crewman are given in Figure 10.

Job knowledge increases rather regularly in all AFQT groups with time. While the spread is less beyond five years than at the beginning, there is no clear evidence for convergence.

Figure 11 shows that the Cook had growth at all AFQT levels with some crossover in the two lowest AFQT groups. Again, there was, however, still no evidence of convergence.

Job Knowledge Test Score by AFQT and Months on Job: Cook

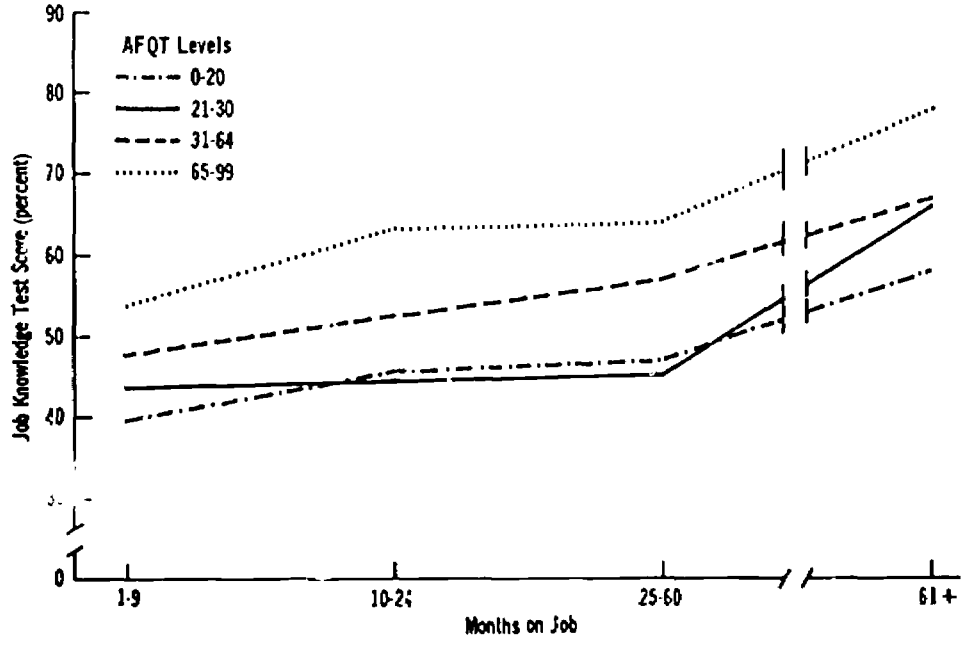

Figure 11

Job Knowledge Test Score by AFQT and Months on Job: Repairman

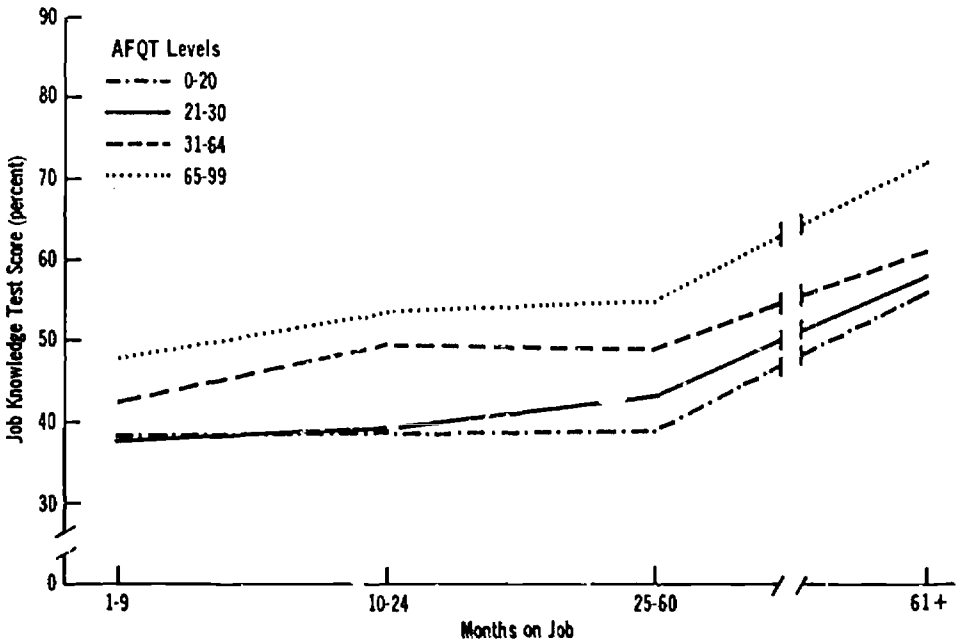

Figure 12

The results for the Repairman test given in Figure 13 show a not dissimilar pattern.

Finally, the job of Specialist Supply shows considerable growth in job knowledge and is the only job in which there is evidence of convergence beyond the five years on the job (see Figure 13).

This may be a ceiling effect as the results of the test show that men get about 80% of the test by the last time interval, whereas in the test results for other jobs the average ranged between 62 and 75%. Because the Supply Specialist job primarily involves the processing of information rather than overt physical performance, the convent of the job knowledge and job sample tests in this speciality are necessarily more alike. It is not surprising that the shapes of their curves are similar. What is a little more difficult to explain is the seeming lack of convergence over time on the other jobs. Since we have seen performance curves generally come together with time, we might expect curves of the knowledge which is required to support performance to do the same. On the other hand, there is more information to be learned about a job than can be adequately represented in the types of tasks one is able to sample in constructing a performance test. (This concerns information which is less frequently required and hence is reviewed on a less frequent basis and often need not be memorized since it is available in some variety of job support.)

While we included some infrequently appearing tasks in our job sample tests, our knowledge tests covered a relatively broader range of job information. Acquisition of such information occurs in a more incidental manner over a longer span of time. With this kind of learning, it is not unreasonable that separation between curves describing this

Job Knowledge Test Score by AFQT and Months on Job: Supply Specialist

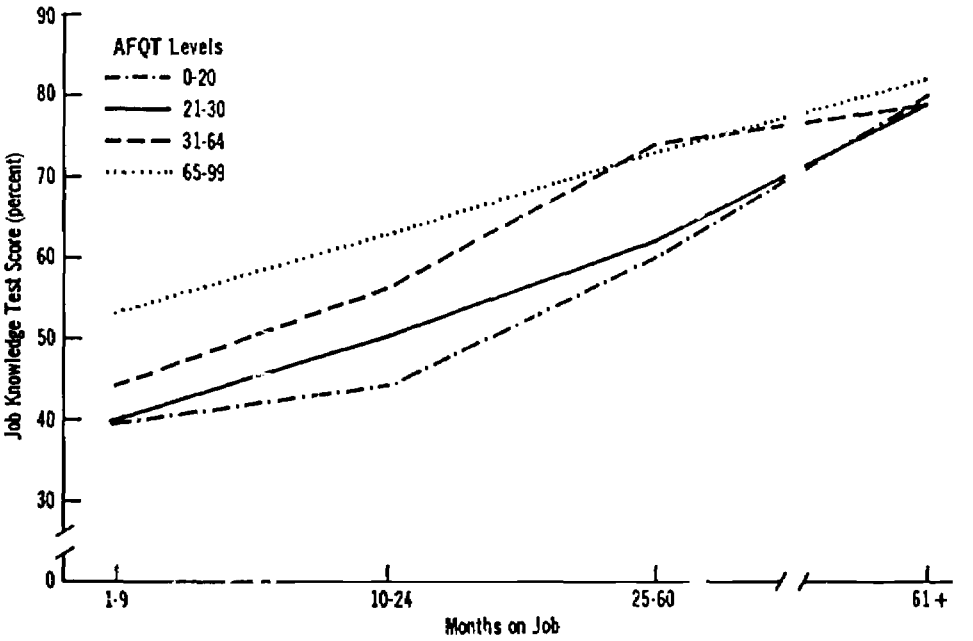

Figure 13

process be maintained. We believe that this is probably the main reason for a lack of convergence in the knowledge curves over the time intervals we have plotted.

The data for all four jobs are so similar that only one, Armor Crewman, is used to show how performance varies in tasks of differing difficulty and complexity with AFQT and time. (See Figure 14). Performance is shown on "easy," "medium," and "difficult" job sample subtests for men with AFQT scores between 1 and 30 and between 31 and 99. Easy, medium, and difficult were defined empirically on the basis of the combined performance of both AFQT groups at all levels of job experience.

In all jobs, the general pattern was clear. Learning occurs at all levels of task difficulty for the two aptitude groups. Performance in easier tasks tends to reach an asymptote with increasing job experience but not in the more difficult tasks. Not surprisingly, the separation between aptitude groups is least in the "easy" tasks. Differences between AFQT groups become greater as difficulty increases.

The clearest pattern of differences between the two aptitude groups as a function of task difficulty, without regard to time, can be seen in Table 2. Here since there were only five Cook subtests, the data were not grouped for these comparisons. The differences between the low aptitude and high aptitude groups increase rather consistently as problem difficulty becomes greater. Combining the jobs, the average difference between groups is 5.8% on the "easy" subtest, 8.8% on the "medium" subtest, and 11.3% on the "difficult" subtest.

Table 3 shows data comparing the performance of low and high aptitude groups on task elements of differing complexity. To do this, each step in a subtest was analyzed

Easy, Medium, and Difficult Job Sample Test Scores by AFQT and Months on Job: Armor Crewman

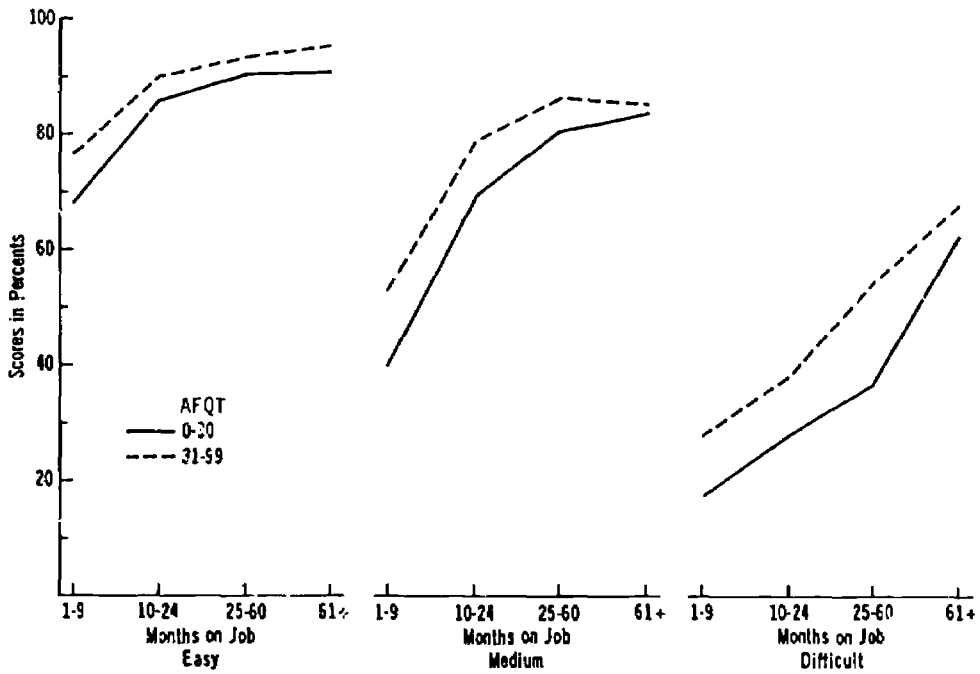

Figure 14

Table 2

Differences in Performance on Easy, Medium, and Difficult Job Sample Tests

(percent)

	Easy	Medium	Difficult
Armor Crewman			
AFQT 31-99	87.7	74.0	44.7
AFQT 0-20	82.4	66.1	33.9
Difference	5.3	7.9	10.8
Repairman			
AFQT 31-99	84.7	73.0	57.9
AFQT 0-20	77.1	64.6	43.4
Difference	7.6	8.4	14.5
Supply Specialist			
AFQT 31-99	73.0	64.2	54.1
AFQT 0-20	68.5	54.1	45.5
Difference	4.5	10.1	8.6

Table 3

Performance of Two AFQT Groups in Two Sets of Behavior Categories: Armor Crewman

(percent)

Categories	AFQT 31-99	Difference	AFQT 0-20	Difference	AFQT 31-99 minus 0-20
N	86.3	5.5	74.7	3.0	11.6
NK_2S	80.8	13.7	71.7	12.1	9.1
NK_2	67.1		59.6		7.5
K_1	71.3	0.1	65.7	2.3	5.6
K_1K_2	71.2	3.2	63.4	3.8	7.8
K_1K_2S	68.0	5.6	59.6	10.6	8.4
$K_1K_2K_3$	62.4		49.0		13.4

according to the degree of structure provided to a subject for accomplishing the step. The structuredness of a step depended on such characteristics as:

(1) Whether the step had been named or identified (e.g., as part of the test instructions or in a manual).
(2) Whether technical or enabling knowledge was required.
(3) Whether the step involved conforming to a precise standard, and, if so, whether the standard had been specified for the subject.

We identified 24 logically possible categories to which subtest steps could be assigned. Using these categories, two mutually exclusive classification sets were developed. The first set contained, regardless of other characteristics, steps that have been named or identified for the subject. The second set contained steps that had not been named but which had to be known by the subject.

This table shows categories and mean scores in the categories which were used in the Armor Crewman job. We considered only categories which contained a reasonably large number of steps and which were represented in at least two of the jobs. The results for Armor Crewman are the only ones discussed since categorization of subtest steps was complicated in the other jobs by the possibility of electing to use a technical manual when the test was taken. No manuals were used in the Armor Crewman tests.

In the uppper set of categories, N stands for the very simplest situation; the step has been named and can be carried out without any additional information. NK_2S stands for a step that has been named but in addition requires some technical knowledge (K_2) and conformance to a precise standard which has been specified for the subject (S). NK_2 stands for a named step which requires technical knowledge. We believe that an NK_2S step is easier than an NK_2 step because, though an additional element is present, specifying the standard to be met in conjunction with actually naming the step provides additional information which serves as a cue to the recall of K_2.

In the lower set, K_1 is a simple step analagous to an N step but one which has not been named for the subject. K_1K_2 is an unnamed step requiring technical knowledge. K_1K_2S is an unnamed step requiring technical knowledge and conformance to a specified

standard. $K_1K_2K_3$ is an unnamed step requiring technical knowledge and conformance to an unspecified standard.

Looking at the mean percent scores, several things should be noted:

(1) Without exception, high aptitude men outperform low aptitude men in each behavior category.

(2) Within each set, the level of performance decreases for lows and highs alike as complexity increases.

(3) In either set, for either group, decrements in performance increase in a positive manner at each successive level of complexity.

(4) In named tasks, where a large proportion of high aptitude men perform successfully, decrements in performance with increasing complexity are relatively greater for high aptitude men. In unnamed tasks, where neither group begins at a very high level, low aptitude men show relatively greater decrements in performance with increasing complexity. The overall effect in named tasks is a decreasing difference between lows and highs as complexity increases. In unnamed tasks, performance differences between lows and highs increase with complexity. Thus, we seem to have a U-shaped relationship. On named tasks (which, other things being equal, are easier) differences between lows and highs decrease as complexity increases, but on the more demanding unnamed tasks, differences between lows and highs grow wider with complexity.

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13. ABSTRACT

This paper is based on data from Work Unit UTILITY research on job performance of men at different ability levels. The paper deals with data testing performance in four jobs; Armor Crewman, Vehicle Repairman, Supply Specialist, and Cook, of various Armed Forces Qualification Test (AFQT) levels over specified periods of time.

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Test Development						
Supply Specialist						