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Measuring General Cognitive Ability in Computer Programmers and Analysts

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Introduction

In hiring decisions, does the quantity and quality of IS experience assure that the person is a top performer? This paper discusses an investigation into this question and concludes that experience alone is not sufficient to identify superior performance. Computer systems are becoming more and more "intelligent". Problems that require intelligent solution approaches are naturally knowledge-intensive, so gathering information from a clerk to develop systems specifications has become the exception rather than the norm. Sophisticated systems require sophisticated knowledge and exceptional ability in the programmers and analysts involved in the system development.

The success of complex systems depends to a great extent on the ability of the analyst to grasp the complexities of the proposed system and of the programmer to apply advanced technologies to operationalize the system's design. For example, superior analysts are able to quickly learn the critical issues in a domain even though they may have had little actual experience in that domain.

Identifying superior performers is a critical task for any IS manager. Although researchers have addressed this issue, few tools are currently available that provide an objective measure of the potential for superior performance, especially when a new graduate is being considered with little experience to indicate their current proficiency, much less their future potential. This paper begins to address the important issue of measuring the potential for superior performance.

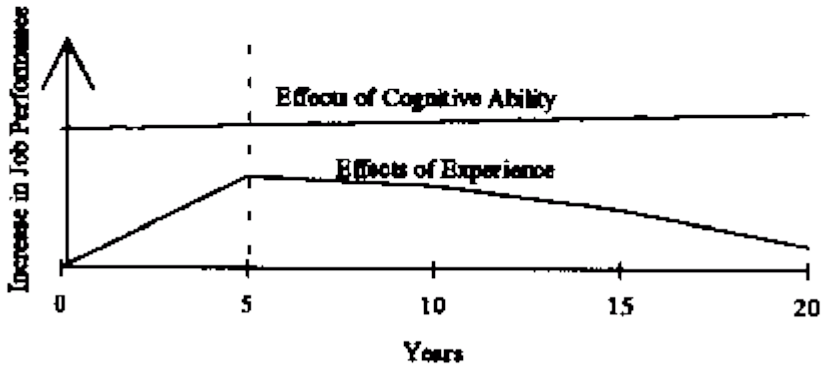
Measures of Superior Job Performance

The most obvious indicators of superior ability are those that can be easily and accurately measured such as years of experience or a person's position in the organization. Experience and position are indicators of seniority but they do not indicate superior task performance. Studies in personnel psychology have had much to contribute to the identification of superior performance for tasks categorized as low to intermediate in complexity and for subjects with less than five years of experience.

In a meta-analysis of the cumulative research on various predictors of job performance, Hunter and Hunter (7) found general cognitive ability to be the most valuable predictor for entry-level jobs (mean validity (Pearson's correlation) of .55) while training and

experience ranked seventh! In other meta-analytic studies, Hunter (4,5,6), determined that the validity of specific aptitude measures stems from their measurement of general cognitive ability. Using a sample of 16,058 workers, McDaniel, et al (10) found that experience was most valid as a predictor of job performance when there are low levels of both task complexity and mean experience (< 5 years). *The validity of experience decreases for more complex tasks and for subjects with higher levels of experience.* Conversely, cognitive ability measures remain high or increase in validity as job complexity increases. Other studies report consistent findings (2,3).

Figure 1
Relative contributions of experience and cognitive ability to job performance for complex tasks (Adapted from Schmidt et al, 1988)



Relative contributions of experience and cognitive ability to job performance

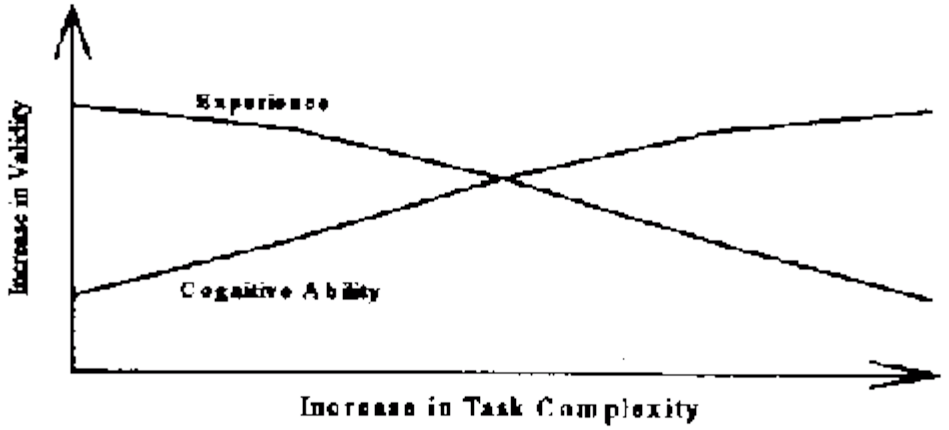
for complex tasks (Adapted from Schmidt et al, 1988)

Figure 1 shows how both experience and cognitive ability contribute to performance. This graph is based on data from four independent studies with a total sample size of 1,474. Mean job experience was 2-3 years. Effects past five years are based on the researcher's extrapolations from the relatively small group with over five years of experience (11). Notice that the predictive value of cognitive ability remains high throughout. This means that after five to ten years of experience, people with low levels of cognitive ability will plateau and no longer appreciably improve their performance. They will be just as proficient after twenty years as they were after ten. People with higher levels of cognitive ability, on the other hand, will continue to improve until they become significantly superior to their peers. They are the ones who become experts. It is these people we want to identify.

Task complexity also has an effect on the validity of predictors of superior performance (10). Figure 2 shows the effect of task complexity on the ability of both experience and cognitive ability to predict expertise. For tasks of low complexity, high levels of

cognitive ability are not required and thus are not as important as experience with the task. For tasks of high complexity, however, cognitive ability is the primary determinant of increases in performance and thus is a much more valuable predictor of expertise. This paper is concerned with identifying people who are superior at performing only complex tasks. Therefore, a measure of cognitive ability seems to be absolutely essential to the discussion.

Figure 2
Effects of task complexity on the validity of measures of experience and cognitive ability



Effects of task complexity on the validity of measures of experience and cognitive ability

Methodology

This study involves the use of three distinct groups, all of which were responsible for the outcome of complex tasks. The first group was composed of 32 instructors and students at the United States Postal Service (USPS) Technical Training Center (1). The instructors were training the students to diagnose problems in a complex piece of mail sorting equipment. The students had very little exposure to the equipment prior to the class sessions, however, each student had over five years of experience maintaining complex machinery and were selected for training based primarily on longevity. The task involved was highly complex, requiring a substantial mental as well as technical ability. These will be referred to as the USPS group.

The second group was composed of programmers and analysts who were involved in software development for a utility company. The study was performed at the end of two major projects that provided significant challenges to the staff. The CIO and other managers were able to assess the performance of each employee in the execution of complex tasks. These will be referred to as the Utility group.

The third group was composed of programmers and analysts in a national software consulting firm. Although this group is much like the Utility group, their customer base is much broader so they are exposed to problems in a greater variety of domains. These will be referred to as the Consulting group.

Measures of experience and cognitive ability were compared to ratings of job performance. Experience was measured by self-reporting years spent performing the tasks germane to their profession . The measure used for performance was the mean rating of the supervising managers based on observed performance.

Cognitive ability was measured using a validated psychological instrument, the Watson-Glaser Critical Thinking Appraisal [44]. The Critical Thinking Appraisal (CTA) is a measure of a composite of attitudes of inquiry, knowledge of the nature of valid inferences, abstractions, and generalizations, and skills in employing and applying these attitudes and knowledge. Critical thinking results from the ability to correctly: define a problem, select pertinent information, recognize stated and unstated assumptions, formulate and select relevant and promising hypotheses, and draw valid conclusions and judge the validity of inferences. These are concomitant aspects of diagnostic problem-solving. Results of other studies using the CTA validate this proposed intent (8). Watson & Glaser (12) recommend the CTA as a tool to determine the relationship between critical thinking abilities and other abilities or traits. In this study, the CTA was used to determine the relationship between critical thinking abilities and superior performance.

Findings

In their meta-analysis of cumulative research on various predictors of job performance, Hunter and Hunter found no predictor better than general cognitive ability (7). Over thousands of studies, cognitive ability and job performance had a mean Pearson's correlation coefficient (validity) of .55 across a variety of job families. These studies involved jobs that varied from low to high complexity. Validity ranged from .27 for cognitively simple jobs to .61 for cognitively complex jobs.

The ratings of observed performance in the USPS group were highly correlated with the scores on the Critical Thinking Appraisal ($n=32$, $r=.85$, $p<.0001$). It is interesting to note that job performance was not significantly correlated ($a=.05$) with measures of recent experience with postal equipment ($r=.12$, $p<.34$) but was significantly correlated with a measure of experience that included performing diagnostics on any kind of electromechanical equipment, including experience gained prior to being employed by the USPS ($r=.26$, $p<.0391$). In other words, experience is not a significant indicator of job performance when only recent experience is considered, but it is significant when the first five years is included. This substantiates the previous supposition that past five years, experience continues to decrease in importance as an indicator of expertise while cognitive ability maintains its importance.

The findings for the Utility group and the Consulting group were significant, but not as strong. The correlations in these groups were $n=26$, $r=.43$, $p<.02$ for the Utility group and

n=38, r=.34, p<.03 for the Consulting group. There are several possible explanations for lower validities in the programmer/analyst groups.

First, these findings are dependent upon the accuracy of the measure of current job performance. The USPS instructors had fairly objective measures of diagnostic performance that were unclouded by personal issues since the instructors and students were only together for two months and did not interact on a personal level. The managers who rated the system development groups were also the hiring managers and were subject to bias stemming from longer-term personal relationships. Another factor that may have influenced the performance ratings is the tasks involved. Although both machine diagnostics (USPS) and system development are very complex tasks, the development of computer systems requires much broader problem-solving skills which are more difficult to rate on a 5-point scale. The USPS group was only expected to solve problems with one machine.

Second, CTA scores are effected by higher education. Only a few of the USPS group members attended college for more than two years. All of the system development group members had a four-year college which effected the variability in their scores.

Third, the USPS group members took the CTA as a part of their training class and were not distracted by the demands of their work. The systems development groups were both under time constraints due to the pressure of meeting development schedules. Since the CTA requires concentration and clear thinking, it is not surprising that the CTA scores were not as accurate a measure for the system development groups.

Overall, the CTA seems to be a consistent indicator of problem solving ability which would make it useful, in conjunction with other tools, in the employment screening process. It could prove especially useful in determining the potential in a new college graduate that has no pertinent experience.

Conclusion

Significant resources are invested each time a person is hired and trained for an IS position. Even if the new employee quickly becomes productive, the break-even point on the investment occurs many months after the hiring decision. If job performance is not at least adequate, then the expense of termination and then going through the hiring process again is a further set-back in accomplishing organizational objectives. On the other hand, a superior performer quickly becomes a profitable investment with many long-term benefits. The findings of this study will assist IS managers in making quality hiring decisions.

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