Applied H.R.M. Research, 2005, Volume 10, Number 1, 13-20

The Impact of Job Knowledge in the Cognitive Ability-Performance Relationship

Mark V. Palumbo, Corey E. Miller, Valerie L. Shalin, & Debra Steele-Johnson

Wright State University

This study compared the efficacy of a job knowledge test in predicting task performance and examined the mediating effect of job knowledge in the cognitive ability-performance relationship. Two hundred undergraduates completed a test of cognitive ability and a written job knowledge test, and then performed a computer-generated truck dispatching simulation. Results demonstrated that job knowledge was a better predictor of task performance than was cognitive ability. Furthermore, the scores from the job knowledge test mediated the effects of cognitive ability on task performance and explained significantly more of the variance in performance than did cognitive ability. These results expand our current understanding of job knowledge as a predictor of performance.

Cognitive ability has been found to be the best, general predictor of performance across a variety of jobs (Hunter & Schmidt, 1996). More specifically, whereas cognitive ability has been correlated highly with job performance (r =.51), other general predictors have somewhat lower correlations (e.g., integrity tests, r = .41; conscientiousness tests, r = .31; biographical data measures, r =.35; and reference checks, r =.26), although equivalent prediction might be obtained using specific predictors (eg., work samples, r = .54) (Schmidt & Hunter, 1998). As a result, cognitive ability has been used frequently as a predictor of performance for employee selection. However, there has been little research examining the mechanisms through which cognitive ability affects performance. Thus, we are suggesting that research that leads to a better understanding of the cognitive ability-job performance relationship may lead to better prediction. More specifically, we propose that cognitive ability affects the acquisition of job knowledge and that job knowledge in turn affects performance.

Hunter (1986) has identified a strong relationship between general cognitive ability and job knowledge and between job knowledge and performance. Furthermore, Hunter and his associates (Hunter, 1993; Schmidt, Hunter, & Outerbridge, 1986) have begun to examine this relationship in more detail, examining job knowledge as a mechanism through which cognitive ability affects job performance. Their research has provided initial evidence that cognitive ability affects performance indirectly through its effects on job knowledge. However, relatively few studies have examined this issue. Moreover, in these mediation studies the construct of job knowledge has not been well defined, even in more recent papers (Schmidt & Hunter, 1998). We believe that it may be possible to obtain better prediction by focusing on job knowledge rather than general cognitive

ability. This idea has support in existing literature (e.g., Miller, Barrett, & Doverspike, 1998; Dye, Reck, & McDaniel, 1993). Therefore, the purpose of this paper is to replicate and extend Schmidt and Hunter's work by offering a closer examination of relationships between cognitive ability, job knowledge, and performance, using a measure of job knowledge derived from a more comprehensive definition of the construct.

Prior definitions have identified job knowledge as technical information, facts, and procedures required to do the job (e.g., Hunter, 1993; Schmidt, Hunter, & Outerbridge, 1986). Job knowledge had a stronger effect on job performance in military samples than civilian samples (Schmidt et al., 1986), but the authors hypothesized that the finding was due to the military's emphasis on procedures. We suggest that research that explores further the role of job knowledge might be informative, especially with civilian samples. Potential benefits might be a better understanding of the ability-performance relationship and improved prediction. Thus, in the current study we examined a model that tested job knowledge as a mediator in the relationship between cognitive ability and performance.

Background

In industry, written job knowledge tests are used for candidate selection, job placement, and organizational advancement considerations. Job knowledge tests are considered to be samples of the task(s) performed on the job. Thus, written tests are developed to reflect the requirements for successful job performance. The test is designed to capture the content of the job within the elements included in the test. The degree of content validity is a measure of the amount of overlap between test content and the job. These written tests are seen as practical for measuring job performance because of the relatively low cost and ease of their administration. Additionally, these paper-and-pencil tests are correlated with hands-on measures of job performance, although the correlations are not strong enough to support the use of these job knowledge tests as a substitute for hands-on measures, i.e., job samples (Dubois & Shalin, 1995).

Traditionally, in Industrial/Organizational (I/O) psychology, the process of constructing job knowledge tests begins with an analysis of the job. In this analysis process, subject matter experts (SMEs), usually job incumbents and/or job supervisors, identify individual tasks, behaviors, and abilities that are necessary for successful task performance (see Cascio, 1998, for a detailed discussion of the test development process.) This identification process results in the definition of the task domain by identifying categories of independent dimensions of successful job performance. Additionally, the process identifies the specific task elements required for task performance. Next, the identified task elements are rated as to their importance and frequency of use in the job. This process of rating possible test items may be completed by the same group who generated the original list or by another group of job incumbents/supervisors. Those items that meet pre-established criteria are included in the written test.

However, we believe that this type of test may be limited because it captures only declarative and procedural knowledge that relate to the task. That is, this

"traditional" type of test captures only information about what to do within the task and how to do it. We believe that any test of job knowledge must include also relevant decision-making information. Thus, the job knowledge test used in this study includes information about why to do a specific procedure in order to successfully complete the task. In summary, to create a test based on a somewhat different definition of job knowledge, we used a procedure influenced by cognitive psychology (see Dubois & Shalin, 1995 for a complete discussion of this approach to test development.)

Method

Participants

Participants (*N* = 207) were obtained from a pool of undergraduate students at a mid-western university who participated in exchange for extra credit points. Seven participants were removed from the sample due to missing data. Thus, data from 200 participants were available for analysis. Of this sample, 127 (63.5%) were women, and 73 (36.5%) were men. Participants performed one 10-minute practice trial (Trial 1) and four 10-minute performance trials (Trials 2 – 5) of the dispatching task.

Task Description

Participants performed a computer-based truck dispatching simulation task (Steele-Johnson & Perlow, 1989), developed for use in the laboratory setting. In this task, participants were required to receive, process, and ship orders of office supplies to various areas within the city. Eight rules constrained how these orders can be processed. Rules included information about identifying order types, order delivery schedules, truck capacity restrictions, and delivery area restrictions. Running task time was identified as the time spanning one working week. That is, the task time began at 9:00 a.m. on Monday and ended at 5:00 p.m. Friday. Each hour interval in the task was equivalent to 15 seconds in real time. Each day in the task corresponded to two minutes in real time. Each task trial lasted 10 minutes. All participants received task instructions prior to attempting the task.

Measures

Demographics

Demographic information was collected using a paper-and-pencil questionnaire designed for this study. Demographic items included age, gender, college ranking (Freshman, Sophomore, Junior, Senior), college major, G. P. A., and plans after graduation (Graduate school, Work, Undecided, Other).

Cognitive Ability

Cognitive ability was assessed at the beginning of the session using the Wonderlic Personnel Test (Wonderlic, 1992). The measure is a 12-minute, speeded test, with a total of 50-items. This measure assesses verbal, mathematical, and analytical general ability levels. The reported test-retest reliability of this measure ranges from .82 to .94.

Job Knowledge Test

Job knowledge was assessed using a 24-item paper-and-pencil measure, designed for this study that employed a cognitively-oriented approach to test development. The internal consistency reliability coefficient for this measure was .89. The test was designed to measure the qualitative components of an individual's overall knowledge and understanding of task requirements, procedures, and their appropriate applications for successful task completion. A multiple-choice framework with five response options was used. The test score was calculated as the sum of the correct responses. Sample questions: "If you attempt to ship a truck that is overloaded by 5 units:" (Answer: "The truck will go out, and a penalty is assessed."). "If you attempt to ship a truck that is loaded with 42 or more items:" (Answer: "The truck will not go out, and a penalty is assessed."). These questions required the individual to understand that there was a predetermined maximum truck capacity, they had exceeded truck capacity by a specific amount, and that consequences existed for attempting to ship that specific truck.

Task Performance

Task performance was operationalized as participants' performance scores on each trial, as awarded by the computer. Participants received 5 points for each unit of office equipment correctly shipped and lost 10 points for each rule violation. Data from performance on Trials 2 through 5 were used in tests of hypotheses.

Procedure

Each participant completed the demographics questionnaire prior to beginning the task. Next, participants completed the Wonderlic Personnel Test (a timed test of cognitive ability), received task instructions, and performed one 10-minute practice trial (Trial 1). Next, participants completed the written measure of job knowledge. Finally, participants completed four more 10-minute trials of the dispatching task (Trials 2-5).

Results

A series of regression analyses with repeated measures were used to test the hypothesized mediation models according to procedures described by Baron and Kenny (1986). Repeated measures analyses were used to examine whether cognitive

Table 1
Means, Standard Deviations, and Correlations of Study Variables

Variable	Mean	SD	Correlations					
			1	2	3	4	5	6
Task performance								
Trial 1 (1)	- 48.2	493						
Trial 2 (2)	299.2	838	.52†					
Trial 3 (3)	670.0	913	.31†	.60†				
Trial 4 (4)	1042.8	848	.29†	.52†	.68†			
Trial 5 (5)	1366.3	771	.15*	.35†	.54†	.80†		
Job knowledge (6)	11.21	4.47	.21**	.43†	.48†	.44†	.35†	
Cognitive ability (7)	21.37	5.16	.17*	.24***	.35†	.31†	.28***	.48†

* $p < .05$, ** $p < .01$, *** $p < .001$, † $p < .0001$

Note: Trial 1 refers to task performance during the practice trial

ability and job knowledge on performance differed as a function of task experience. Means, standard deviations, and intercorrelations between study variables are shown in Table 1.

Job Knowledge as a Mediator of Cognitive Ability Effects on Performance

A series of regression analyses with repeated measures was used to examine the role of job knowledge as a mediator of the effects of cognitive ability on task performance. First, we examined the effects of cognitive ability (predictor) on task performance (criterion). Results indicated a significant effect for trial [Wilks' Lambda = 0.42, $F(3, 196) = 92.05$, $p < .0001$]. Performance improved across trials. Additionally, results indicated significant effects for cognitive ability [$F(1, 198) = 27.3$, $\beta = 0.35$, $p < .0001$] and the Trial by Cognitive Ability interaction [$F(3, 196) = 2.62$, $p = .05$]. Thus, cognitive ability effects differed, depending on task trial. Given that the interaction effect was not a central issue in our study, we were primarily concerned about determining whether cognitive ability effects were significant in each of the task trials. And, indeed, follow-up analyses indicated that cognitive ability was significantly related to performance in all task trials [$F(1, 198) = 11.58, 27.00, 20.81, 14.06$, $\beta = 0.24, 0.35, 0.31, 0.26$, all ps $< .001$, for Trials 2 through 5, respectively]. Overall, cognitive ability accounted for 12% of the variance in task performance. There were no other significant effects.

Second, a regression analysis with repeated measures was used to examine the effects of job knowledge (mediator) on task performance (criterion). Results indicated a significant effect for trial [Wilks' Lambda = 0.41, $F(3, 196) = 93.78$, $p < .0001$]. Performance improved across trials. Additionally, results indicated a significant main effect for job knowledge [$F(1, 198) = 71.33$, $\beta = 0.51$, $p < .0001$]. Job knowledge was positively associated with task performance. Furthermore, results indicated a significant effect for the Trial X Job knowledge interaction [Wilks' Lambda = 0.94, $F(3, 196) = 4.07$, $p < .01$]. To examine the interaction effect further, the effect of job knowledge was examined within trials. Once again, our

primary concern was to determine whether job knowledge had effects on performance in each of the four task trials. Results of follow-up analyses indicated that job knowledge had a significant effect on performance in all task trials [$F(1, 198) = 44.81, 60.34, 46.63, 27.10$, βs = 0.43, 0.48, 0.44, 0.35, all p's < .0001, for Trials 2 through 5, respectively]. Overall, job knowledge accounted for 26% of the variance in performance. There were no other significant effects.

Third, a regression analysis was used to examine the effects of cognitive ability (predictor) on job knowledge (mediator). Results indicated a significant main effect for cognitive ability [$F(1, 198) = 59.76$, $\beta = 0.48$, $p < .0001$]. Thus, cognitive ability was positively related to job knowledge, accounting for 23% of the variance.

Finally, to examine job knowledge as a mediator, cognitive ability was entered into the model after controlling for the effects of job knowledge. Results indicated a significant effect for trial [Wilks' Lambda = 0.41, $F(3, 195) = 93.41$, $p < .0001$], job knowledge [$F(1, 197) = 72.26$, $\beta = 0.51$, $p < .0001$], and the Trial X Job knowledge interaction [$F(3, 195) = 4.07$, $p < .01$]. Thus, performance improved across trials and was differentially affected by levels of job knowledge. Job knowledge was positively related to task performance. However, the effect of cognitive ability fell to a non-significant level [$F(1, 197) = 3.57$, $\beta = 0.13$, $p > .05$] after controlling for the effects of job knowledge. Furthermore, the variance in performance accounted for by the model increased from 26% (accounted for by job knowledge) to only 28% with the inclusion of cognitive ability. That is, although cognitive ability accounted for 12% of the variance in performance when entered as a single factor, cognitive ability accounted for only an additional 2% of the variance in performance, after controlling for the effect of job knowledge. Thus, in this model, job knowledge ***completely mediated*** the effects of cognitive ability on task performance.

Discussion

In the current study, we used a written measure of job knowledge that was developed using a cognitive approach. Results demonstrated that job knowledge mediated the relationship between cognitive ability and performance. Thus, our results provide evidence that job knowledge is a mechanism through which cognitive ability influences performance. Furthermore, the job knowledge measure was a stronger predictor of performance than cognitive ability. Whereas cognitive ability accounted for only 12% of the variance in performance, job knowledge accounted for 26% of the variance. We suggest that this increased prediction is due to the fact that we directly measured job knowledge rather than measuring only cognitive ability, which is related to performance through job knowledge. This approach is consistent with Binning and Barrett (1989) and has been subsequently used as a basis for the *Standards* (American Educational Research Association, 1999). The Standards suggest that content valid tests may be directly measuring an aspect of job performance; however, a criterion-related validation design (such as would be used to validate cognitive ability) will result in measuring job performance indirectly through another measure.

We concede that job knowledge tests cannot be used to select applicants with no prior related experience. Thus, in general, job knowledge tests alone cannot be used for initial selection for a position. However, we believe that it is possible to measure the amount of knowledge that has been acquired after minimal task instruction and practice. Thus, a job knowledge test might be used in conjunction with pre-hire training to select applicants for jobs. Moreover, job knowledge tests might be used in conjunction with existing training programs for job incumbents to select or place incumbents in other jobs in the organization. Further, job knowledge tests can be used to assess the learning that occurs as an outcome of training in order to evaluate training program effectiveness. Finally, job knowledge tests could be used in promotion decisions for job incumbents. Safety forces (e.g., police and fire) are one example of job families that might benefit from this approach. For example, in some cases, final hiring decisions for safety forces currently are made following provisional hiring and completion of an extensive training program. Also, job knowledge tests could be used in promotion decisions for incumbents in safety force jobs.

In summary, our results provide evidence that job knowledge tests provide a better prediction of future job performance than cognitive ability tests. Although job knowledge tests may be more expensive to develop and administer, relative to cognitive ability tests, job knowledge tests provide a better prediction of performance and might be particularly beneficial to use in situations in which selection or promotion errors are expensive for the organization. If it is expensive for the organization to make selection errors, then assessment of job knowledge is beneficial.

References

American Educational Research Association, American Psychological Association, National Council on Measurement in Education (1999). *Standards for Educational and Psychological Testing.* Washington, DC: Author.

Binning, J. F., and Barrett, G. V. (1989). Validity of personnel decisions: A conceptual analysis and evidential bases. *Journal of Applied Psychology, 74,* 478-494.

Cascio, W. F. (1998). *Applied psychology in human resource management.* Upper Saddle River, NJ: Prentice Hall.

Dubois, D. A. and Shalin, V. L. (1995).Adapting cognitive methods to real-world objectives: An application to job knowledge testing. In P. D. Nichols, S. F. Chipman, R. L. Brennan (Eds.), *Cognitively Diagnostic Assessment* (pp. 189-220). Hillsdale, NJ: Lawrence Erlbaum Associates.

Dye, D. A., Reck, M., & McDaniel, M. A. (1993). The validity of job knowledge measures. *International Journal of Selection and Assessment, 1,* 153-157.

Hunter, J. E., & Schmidt, L. (1996). Intelligence and job performance: Economic and social implications. *Psychology, Public Policy, & Law, 2(3-4),* 447-472.

Hunter, J. E. (1993). A causal model of cognitive ability, job knowledge, job performance, and supervisor ratings. In F. J. Landy, S. Zedeck, & J. Cleveland (Eds.*), Performance Measurement and Theory* (pp. 257-266). Hillsdale, NJ: Lawrence Erlbaum Associates.

Hunter, John E. (1986). Cognitive ability, cognitive aptitude, job knowledge, and job performance. *Journal of Vocational Behavior*, *29(3)*, 340-362.

Miller, C. E., Barrett, G. V., & Doverspike, D. (1998). A case study versus science. *American Psychologist*, *53*(5), 569-570.

Schmidt, F. L., & Hunter, J. E. (1998). The validity and utility of selection methods in personnel psychology: Practical and theoretical implications of 85 years of research findings. *Psychological Bulletin*, 124, 262-274**.**

Schmidt, F. L., Hunter, J. E., & Outerbridge, A. N. (1986). Impact of job experience and ability on job knowledge, work sample performance, and supervisory ratings of job performance. *Journal of Applied Psychology*, 71, 432-439**.**

Steele-Johnson, D. & Perlow, R. (1989). Development of software for a trucking dispatch task. Unpublished paper.

Wonderlic, E. F. (1992). *User's Manual for the Wonderlic Personnel Test and Scholastic Level Exam.* Libertyville, IL: Wonderlic Personnel Test, Inc.

Author Note

Please send correspondence to:

Mark V. Palumbo
Wright State University
3640 Colonel Glenn Hwy.
Dayton, OH 45345
Phone: (937)-775-3527
Fax: (937)-775-3347
Email: palumbo.2@wright.edu