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Trainability and the Prediction of Training Performance: Basic Skills, Cognitive Ability, or Both?

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Trainability and Training Performance: Basic skills, Cognitive Ability, or Both?

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This study investigated Noe and Colquitt's (2002) concept of training readiness, also termed trainability. Trainability is purported to include both basic skills (e.g., reading and mathematics skills) and cognitive ability. We examined trainability as a potential predictor of training success, using the Kraiger, Ford, and Salas (1993) three-factor training performance model. Basic skills and cognitive ability were found to predict pre-selection screening outcomes and subsequent training performance. Trainability's strength of prediction varied depending on the training criterion-type. Additionally, cognitive ability was found to mediate the relationship between basic skills and training performance.

As a complex phenomenon, training effectiveness encompasses many variables, including trainee characteristics, training characteristics, contextual factors, and training criteria (Cannon-Bowers, Salas, Tannenbaum, & Mathieu, 1995). The interaction between the characteristics of the trainee and the training situation can be used to address important questions about effectiveness: Is the training equally effective for all trainees? Over a decade ago, Tannenbaum and Yukl (1992) indicated the need for more research relating individual differences to training effectiveness. Since then, research investigating the role of individual characteristics in training performance has increased dramatically (e.g., Colquitt, LePine, & Noe, 2000; Facteau, Dobbins, Russell, Ladd, & Kudisch, 1995; Martocchio & Judge, 1997) with many positive implications for practice, as well as substantial theoretical contributions to understanding the training process (Salas & Canon-Bowers, 2001). Noe and Colquitt (2002) described four basic components of individual characteristics relevant to training effectiveness: (1) readiness to learn, (2) motivation to learn, (3) actual learning, and (4) transfer of learning to the job. With some notable exceptions (e.g., Ree & Earles, 1991), the majority of recent training research has mainly focused on the latter three components of individual characteristics. In terms of the implementation of training programs, Salas, Canon-Bowers, Rhodenizer, and Bowers (1999) comment that an all-to-commonly held myth is that every employee is ready for training. Considering both the need for additional empirical work and the potential practical benefits for training outcomes, we chose to specifically examine issues of individual differences in training readiness and training performance.

In an augmentation of their original model (Colquitt et al., 2000), Noe and Colquitt (2002) expanded the concept of training readiness, also termed "trainability," to included both cognitive ability and basic skills. They described trainability as the "ability to the learn content of the training program [and that] individuals are trainable depending on their general cognitive ability (that is, intelligence) and their possession of basic skills such as reading, writing, and mathematics" (p. 59). The wealth of general cognitive ability research has clearly demonstrated its importance and central role in successful training performance (Ree & Carretta, 1998; Ree, Carretta, & Teachout, 1995; Ree & Earles, 1991). The promise embedded in adding the notion of basic skills to trainability is that, unlike general cognitive ability, individuals lacking basic skills can be afforded the opportunity to improve these skills through efforts such as remedial training (Noe & Colquitt, 2002). This situation potentially provides both organizations and individuals with more realistic options for human resources functions such as personnel screening and selection, as well as employee training and development.

Historically, researchers have quite frequently examined the influence of cognitive ability in training situations (e.g., Fox, Taylor, & Caylor, 1969; Mobley,

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Hand, Baker, & Meglino, 1979; Neel & Dunn, 1959; Tubiana & Ben-Shakbar, 1982). In more recent years, the use of cognitive ability in training performance models has continued (e.g., Bell & Kozlowski, 2002; Cannon-Bowers et al., 1995; Livens, Harris, Van Keer, & Bisqueret, 2003; Olea & Ree, 1994). Research examining general cognitive ability and training success has led some researchers to state that training proficiency is "not much more than g" (Ree & Earles, 1991) and that the influence of specific abilities, although significant, is quite minimal (Ree, Carretta, & Steindl, 2003). However, several authors have cautioned this conclusion citing that the lack of incremental prediction may be attributable to criterion deficiency (Tenopyr, 2002; Viswesvaran & Ones, 2002). These authors have also called for additional research using more refined criteria. Relevant to the concept of trainability, Noe and Colquitt (2002) specifically purport the role of basic skills, which may or may not be identical psychological entities to the specific abilities used in previous studies. Considering these issues, we chose to examine the components of trainability using a more comprehensive training criterion space which included cognitive, affective, and skill-based outcomes (Kraiger, Ford, & Salas, 1993). To date, we have not found any research investigating the viability and usefulness of the trainability concept, as defined by cognitive ability and basic skills, using the Kraiger et al. (1993) criterion model.

The purpose of our study was to examine the utility of the trainability concept, through investigating the distinctiveness of basic skills and cognitive ability as concept components, as well as the predictive potential of trainability in pre-selection screening outcomes and subsequent training success. Essentially, we asked the following research questions: Are there individual differences in trainability associated with pre-selection screening outcomes? Do levels of trainability predict ensuing training performance? What roles do cognitive ability and basic skills play in trainability and its potential utility as a predictor? These questions hold both theoretical and practical importance. Unlike the specific abilities from previous research, basic skills may be predictive of training performance beyond general cognitive ability, especially when using a more complete assessment of training outcomes. This type of evidence could be seen as similar to issues in the personality literature surrounding the Five Factor Model versus the circumplex models (Hofstee, de Raad, & Goldberg, 1992; Johnson & Ostendorf, 1993) in which increased specificity has been shown to sometimes result in better prediction of performance. As previously mentioned, basic skills are also trainable, thus allowing an alternative for individuals of varying general ability levels. The need for research focusing on ability levels of trainees at both ends of the continuum (high and low general cognitive ability) and how to optimize their learning has been solicited (Salas & Canon-Bowers, 2001). Finally, basic skill tests may be less susceptible to perceptions of unfairness than general cognitive ability tests as their specificity could translate into perceptions of job-relatedness (Kehoe, 2002).

Methods

Participants & Training Context

The study's participants were soldiers in the United States Army participating in Special Forces Assessment and Selection (SFAS) and the ensuing Special Forces Qualification Course (SFQC). The SFAS is a pre-selection screening process in which individuals complete a variety of psychological, physical, and skill-related assessments. A more detailed description of SFAS can be found in Brooks (1997) or Marrs (2000). Soldiers meeting the standards of SFAS (i.e., pass the pre-selection screening) enter SFQC, which is considered the formal training component. During SFQC, a soldier's only responsibility is the successful mastery of training content and completion of the course. The usable sample size for participants from SFAS was 1122 and 275 from SFQC. All data used in this study were derived from archival sources.

Measures

General cognitive ability. The *Wonderlic Personnel Test* (WPT: Wonderlic, 1984) was used as a measure of cognitive ability. The WPT is a general cognitive test that has been used extensively for both research and practice (e.g., Chan, 1997; Stone, Stone, & Guetal, 1990) and yields a single score. Test-retest reliabilities for the WPT range from the .70's to .90's.

Basic skills. Measures of basic skills were taken from the *Test of Adult Basic Education* (TABE: McGraw-Hill, 1987). The TABE scores used for this study consisted of four subtests: Reading comprehension, Number operations, Language, and Vocabulary. Internal consistency reliabilities for these specific TABE tests range from the low .80's to the low .90's.

Training criteria. We created three composite scores to represent the 3 components of the Kraiger et al. (1993) training performance model. A confirmation of the model used in this study with a larger sample of Special Forces (SF) soldiers can be found in Surface (2003). The *cognitive* measure was a composite of scores from three separate exams: a land navigation exam, a small unit tactics exam, and a mission planning exam. Subject matter experts with operational experience in SF constructed all tests. The *affective* measure was a composite score of peer ratings and rankings. The peer ratings were on the dimensions of effort and persistence (keeps going when things get tough; works hard even when cadre are not around; is always determined to succeed) and teamwork (contribution to the team effort; loyalty to the team; trustworthy). Peer rankings were the rank order of fellow training team members from best to worst in terms of overall performance. The number of people providing the rankings varied from team to team, so the number of team members providing rankings was captured and used to standardize the ranks. The *skill-based* measure was a composite score of two times-to-criterion measures and a count of "spot reports." The spot reports reflected observations of critical incidents of "positive" and "negative" behavior. The times-to-criterion measures were taken from the number of iterations required to successfully complete and master two field-training exercises: land navigation skills and small unit tactics skills.

Analytic strategy

In order to investigate the influences of trainability in the pre-selection screening process (i.e., SFAS), we conducted a multivariate analysis of variance (MANOVA) with cognitive ability and the four basic skills as independent variables and the dependant variable of pre-selection screening outcome ("pass" or "fail"). To examine the relative contributions of the components of trainability to predicting ensuing training performance, we calculated estimates of relative weights and corresponding percentages of the overall criterion variance accounted for. Relative weights represent the proportional contribution of each independent variable to the prediction of the dependant variable, considering both its unique contribution and its contribution when combined with the other predictors (Johnson, 2000). These estimates are particularly useful when independent variables are correlated, as was expected among the cognitive ability and basic skill measures. Finally, we used path analysis to further investigate the nature of trainability's influence on subsequent training performance and to examine the specific role each trainability facet plays in this influence. Specifically, we tested three separate path models: (1) direct effects with equal antecedents, (2) basic skills mediating and/or partially mediating the relationship between cognitive ability and training performance, and (3) cognitive ability mediating and/or partially mediating the relationship between basic skills and training performance. Figure 1 displays the three path models.

Results

Table 1 displays the means, standard deviations, and correlations for the variables used in the study. Cognitive ability was significantly related to all three training criteria, with the largest correlation to cognitive training performance. All four basic skills were significantly related to cognitive training performance as well. Language, reading comprehension, and vocabulary were significantly related to affective training performance, while only language and numerical operations were related to skill-based training performance.

Table 1
Descriptive Statistics for Study Variables

	M	*SD*	1	2	3	4	5	6	7	8
1. Language	60.86	8.17	.							
2. Numerical operations	68.57	12.27	.59**	.						
3. Reading	63.66	4.85	.63**	.46**	.					
4. Vocabulary	27.57	2.25	.56**	.38**	.84**	.				
5. Cognitive ability	53.45	30.29	.59**	.57**	.65**	.58**	.			
6. Affective performance	9.36	1.33	.13*	.04	.15*	.12*	.16**	.		
7. Cognitive performance	204.02	18.71	.32**	.27**	.27**	.25**	.38**	.21**	.	
8. Skill-based performance	12.43	1.38	.14*	.14*	.11	.07	.13*	.25**	.20**	.

Note. Basic skills are variables 1-4; training criteria are variables 6-8.
* $p < .05$ ** $p < .01$.

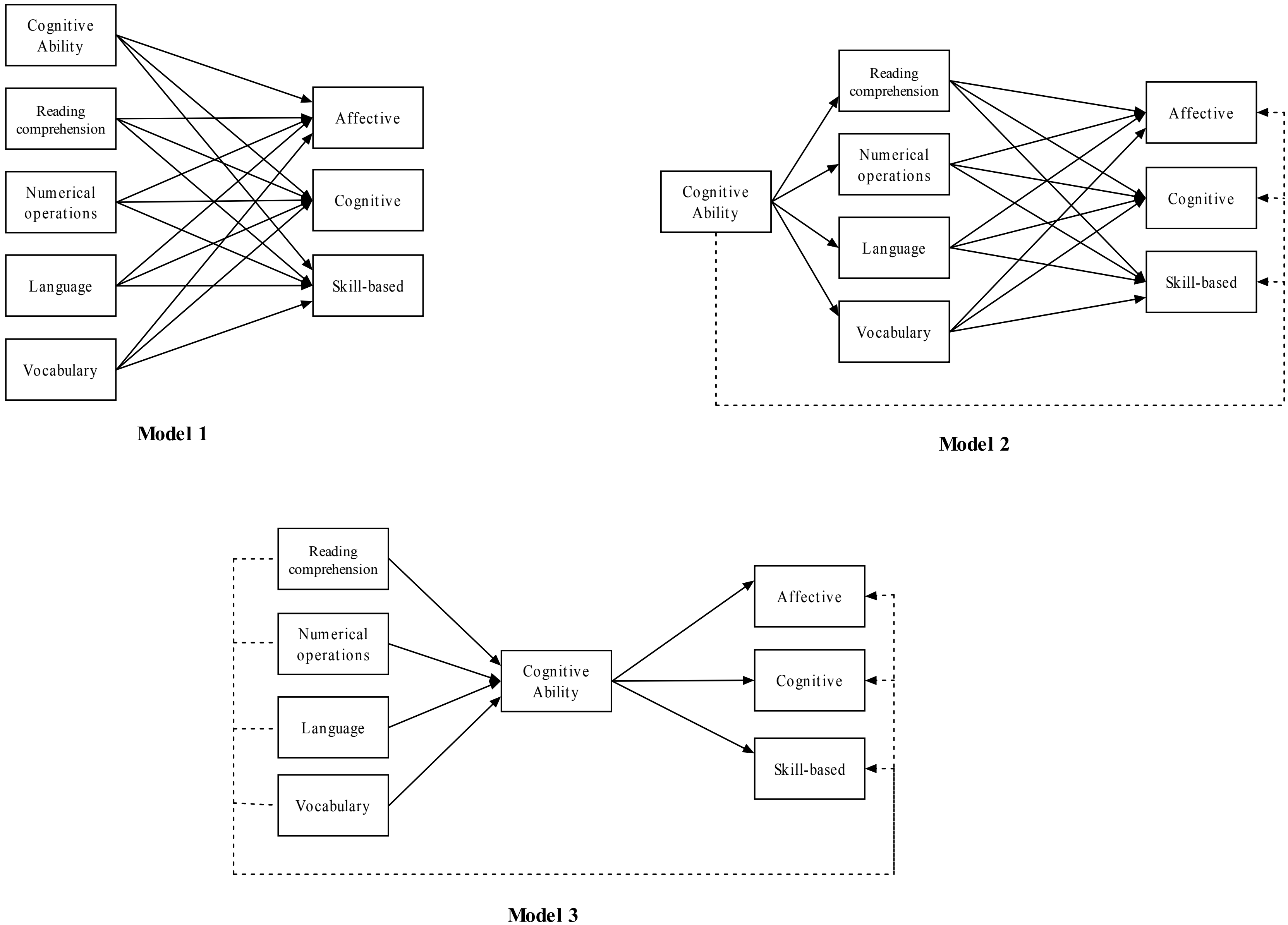

Figure 1. Path models used in study; dashed line represents partially mediated models (models 2b and 3b); error terms have been omitted for clarity.

The MANOVA examining the relationship between trainability and the outcome of pre-selection screening yielded a significant main effect, $F(5, 1120) = 5.37$, $p < .01$. The univariate analysis of variance results are shown in Table 2. All four basic skills and cognitive ability were significant, thus showing that individual differences in trainability profiles influenced pass or fail judgments in SFAS. This evidence suggested that both trainability component types (basic skills and cognitive ability) affected whether individuals were chosen to proceed into the formal training program from the pre-selection screening process.

Table 2

ANOVA for Trainability and Pre-selection Screening

Dependent variable	*F* (*df*)	η^2
Language	19.15 (1,1124)**	.02
Numerical operations	19.82 (1,1124)**	.02
Reading	15.57 (1,1124)**	.01
Vocabulary	13.47 (1,1124)**	.02
Cognitive ability	17.06 (1,1124)**	.02

Note. $N = 1125$; IV = classification of pass or fail screening.
** $p < .01$.

As expected, the basic skills and cognitive ability were significantly correlated, thus justifying the use of relative weights. Relative weights for the trainability components predicting the three training criteria are shown in Table 3. For affective training performance, the percentages of predictable variance accounted for by two of the basic skills (language and reading) were comparable to the percentage contribution for cognitive ability. Cognitive ability had the largest relative contribution to predictable variance in cognitive training performance, although the contribution from the basic skill of language was close. As for skill-based training performance, basic skills clearly contributed larger proportions of predictable variance than cognitive ability. Caution must be warranted, however, in that our R^2 values were low for both affective and skill-based criteria. These low values were likely due to range restriction in our sample as cognitive ability was restricted by the pre-selection screening and the training criteria were restricted by virtue of only using graduates of the SFQC as study participants (i.e., training to mastery in a multiple hurdle process constrains variability). Nonetheless, our findings are similar to previous research (e.g., Colquitt et al., 2000) and the relative weights are still useful in determining the contributions of each component of trainability to the prediction of training performance. Taken collectively, our evidence suggests that basic skills and cognitive ability are both important components of trainability and that their relative importance varies depending on the type of training criteria.

Table 3

Relative Weights of Trainability Predicting Training Performance

Predictor	Training criteria					
	Affective		Cognitive		Skill-based	
	RW	$\%R^2$	*RW*	$\%R^2$	*RW*	$\%R^2$
Language	.010	22.0%	.055	27.6%	.010	29.7%
Numerical operations	.004	8.2%	.024	12.0%	.010	27.1%
Reading	.013	28.7%	.027	13.7%	.008	21.9%
Vocabulary	.007	15.2%	.020	10.2%	.003	7.5%
Cognitive ability	.012	25.9%	.072	36.4%	.005	13.8%

Note. $R^2 = .05$ for affective performance; $R^2 = .20$ for cognitive performance; $R^2 = .04$ for skill-based performance; *RW* = raw relative weight; $\%R^2 =$ raw weight as a percentage of R^2.

Path analyses were conducted using CALIS from SAS®, version 8.2. The fit statistics for the tested path models are shown in Table 4. To evaluate the fit of the path models we used four indices in addition to the χ^2 statistic. These indices were the normed fit index (NFI; Bentler & Bonett, 1980), comparative fit index (CFI; Bentler, 1990), goodness-of-fit index (Jöreskog & Sörbom, 1996: GFI), and the root mean square residual (RMSR; Steiger, 1990). Values for the NFI, CFI, and GFI above .90 are considered indicators of reasonable model fit (Bentler, 1990), while RMSR values of less than .08 are indicative of excellent fit, with .10 as an upper limit (Vandenberg & Lance, 2000). As can be seen in the table, Model 1 (i.e., direct effects from basic skills and cognitive ability) provided an adequate fit of the data. Models 3a and 3b (i.e., cognitive ability as a mediator and partial mediator, respectively) also provided adequate fit. As Model 3a is nested in Model 3b, a test of χ^2 differences may be used to compare the models. The $\Delta\chi^2$ value was not significant, thus the addition of direct paths from basic skills to training performance did not significantly improve model fit. Model 1 and Model 3a were not nested and thus could not be directly compared in terms of fit. The important difference between these two models is that Model 1 posits all predictors as equal antecedents with direct effects on the training outcomes, whereas Model 3a posits cognitive ability as a mediator of the relationship between basic skills and training outcomes. Based on prior literature describing the role of general cognitive ability in predicting training and job performance (e.g., Ree et al., 2003), we considered the latter model as more appropriate and interpretable.[1]

Table 5 shows the standardized path coefficients (i.e., beta weights) for Models 1 and 3a. For the direct effects model, only two paths were significant: (1) the basic skill of language to cognitive training performance and (2) cognitive ability to cognitive training performance. Perhaps manifesting the appropriateness of Model 3a's interpretability over the direct effects model (Model 1), is how the portrayal of cognitive ability as a mediating influence induced an increase in the number of significant model paths. Three of the four basic skills showed significant paths to cognitive ability, while cognitive ability significantly mediated these relationships to all three training outcomes. This evidence suggests that the nature of trainability's influence on training outcomes is not necessarily a direct effects model, but rather one trainability component (cognitive ability) regulates the flow of influence from other trainability components (basic skills) to training performance.

Discussion

Colquitt and his colleagues (2000) indicated that "because acquisition of knowledge and skill depend on learning and because learning depends on individual differences in *g* [general cognitive ability], *g* should predict success in training" (p. 680). Research has supported this statement (e.g., Ree & Earles, 1991). Recently, Noe and Colquitt (2002) expanded the definition of trainability beyond just cognitive ability to also include basic skills. Our aim was to examine the utility of including basic skills in addition to cognitive ability as predictors of training success.

Table 4

Fit Statistics for Path Models

	χ^2	*df*	$\Delta\chi^2$	RMSR	CFI	GFI	NFI
Model 1	24.52**	3	-	.048	.98	.98	.97
Model 2a	359.94**	12	-	.125	.77	.61	.61
Model 2b	346.97**	9	12.97**	.119	.78	.62	.62
Model 3a	44.01**	15	-	.064	.96	.97	.95
Model 3b	24.52**	3	19.49	.048	.98	.98	.97

Note. Model 1 = equal predictors; Model 2a = basic skills as mediators; Model 2b = basic skills as partial mediators; Model 3a = cognitive ability as mediator; Model 3b = cognitive ability as partial mediator.
* $p < .05$ ** $p < .01$.

Table 5

Parameter Estimates for Models 1 and 3

	Predictor	Criterion	*B*
Model 1	Language	Affective performance	.08
		Cognitive performance	.19**
		Skill-based performance	.09
	Numerical operations	Affective performance	-.12
		Cognitive performance	.01
		Skill-based performance	.06
	Reading	Affective performance	.14
		Cognitive performance	.04
		Skill-based performance	.12
	Vocabulary	Affective performance	-.04
		Cognitive performance	-.01
		Skill-based performance	-.10
	Cognitive ability	Affective performance	.11
		Cognitive performance	.27**
		Skill-based performance	.03
Model 3a	Language	Cognitive ability	.16**
	Reading	Cognitive ability	.28**
	Numerical operations	Cognitive ability	.32**
	Vocabulary	Cognitive ability	.11
	Cognitive ability	Affective performance	.16**
		Cognitive performance	.41**
		Skill-based performance	.13**

Note. Model 1 = equal predictors; Model 3a = cognitive ability as mediator.
**$p < .01$.

Overall, we found some supportive evidence suggesting that basic skills do have influential roles beyond cognitive ability in degrees of training readiness and training performance. However, we also found that these influences varied depending on training criterion and that the antecedent influences of basic skills were mediated by cognitive ability.

We found individual differences in trainability to be associated with pre-selection screening outcomes. In addition, both trainability component-types (cognitive ability and basic skills) were important in this relationship. Our findings suggest that there are differences in individual profiles of trainability and these differences are related to pre-selection screening decisions. This evidence provides initial support for the viability of using trainability, as composed of basic skills and cognitive ability, as an assessment of training readiness. These results are compelling in that important aspects of the screening process (i.e., SFAS), in terms of whether a soldier passes or fails, are also comprised of physical assessments (e.g., fitness tests and physically challenging events). Despite this significant non-psychological nature of SFAS, trainability appeared to play an additional role in predicting training outcomes, at least in the context of a pre-selection screening process.

Perhaps, more interesting, were our results from the relative weight analyses investigating the utility of trainability in predicting training course outcomes, and the distinctiveness of the various components of trainability in these predictions. Here, our results suggest that basic skills may be comparable to cognitive ability in terms of the relative predictable variance each contributes to training performance. For both the affective and skill-based training outcomes, basic skills were as important to prediction as was cognitive ability. As for cognitive training performance, at least one basic skill (language) was close to strength of cognitive ability. Our R^2s could be considered low, particularly for the affective and skill-based outcomes. However considering prior research, there should be no reason to expect cognitive ability and basic skills to explain massive amounts of variance in skill-based or affective training performance. For example, meta-analytic work by Colquitt and colleagues (2000) found cognitive ability to be correlated .69 with declarative knowledge (i.e., a cognitive outcome), .38 with skill-based performance, and .22 with post-training self-efficacy (self-efficacy is typically used as an affective outcome). These correlation magnitudes mirror what was found in our study. The complete Colquitt et al. (2000) partially mediated model including many individual and situational variables only explained 29% of the variance in skill, whereas 87% of the variance in declarative knowledge and 86% of the variance in post-training self-efficacy were explained. Additionally, they found cognitive ability and motivation to learn explained 63% of the variance in declarative knowledge, 20% in skill, and only 9% in self-efficacy. Therefore, our results can be considered fairly congruent to previous findings.

When collectively considering our results with those from research focusing on general cognitive ability, specific abilities, and prior job knowledge (e.g., Ree at al., 1994; Ree et al., 1995; Ree, Carretta, & Doub, 1998/1999), our evidence suggests that basic skills could be different psychological entities than specific abilities and/or prior job knowledge. For instance, in our study basic skills were generally comparable to cognitive ability in terms of prediction strength, whereas specific abilities in previous research were found to only minimally contribute to performance prediction as compared to general cognitive ability. At the very least, our results portray that basic skills do influence training outcomes relative to cognitive ability. Additional research, particularly at the latent level, examining the predictive roles of basic skills and cognitive ability would be a useful endeavor to help elucidate these processes.

Our path analyses can be considered preliminary investigations into nature of trainability and its influence on training outcomes. Our results indicate the complex role of cognitive ability within the concept of trainability. Specifically, we found cognitive ability to fully mediate the relationship between basic skills and training performance. This evidence makes intuitive sense in that levels of general cognitive ability should be expected to attenuate or accentuate the effects of more specific learning capabilities such as basic skills. This interpretation is also congruent to past descriptions of general cognitive ability as the "ability to learn" (Hunter, 1986). One possible conclusion from our research and the general cognitive ability research is that the ability to learn and training readiness (trainability) are related but distinct learning phenomena, perhaps with differing antecedents as well. Future research will be necessary for more substantial conclusions to be made regarding training readiness and the ability to learn.

Several limitations of our study are important to note. The usable sample size for our predictive analyses was smaller than many prior general cognitive ability studies. Thus, it becomes more difficult to compare our path analytic and incremental prediction findings to those of previous research. In addition, although we used a well-accepted measure of cognitive ability (*Wonderlic Personnel Test*), many past studies have used "psychometric *g*" and have found little incremental prediction for variables beyond the influence of general cognitive ability. Indeed, unlike prior research we chose to focus on cognitive ability and basic skills using a broader operationalization of training performance, rather than specific abilities and general cognitive ability. Nonetheless, this limitation could affect the generalizability of our findings. Other factors potentially influencing the generalizability of our results are the nature of the training context (US Army Special Forces training) and the likely variability in the specific importance of various basic skills across different jobs and performance dimensions. Finally, levels of basic skills could be related to, or moderated by, an individual's level of education. We did not include this variable in our analyses. Additional research is clearly needed in order to cross-validate our findings and to form more concrete conclusions.

In answering the question posed by the title of our manuscript about whether trainability is composed of basic skills, cognitive ability, or some mixture, our findings generally suggest that the answer is both. Collectively, we found basic skills and cognitive ability to be important facets of training readiness. However, we also found evidence to support the argument that the influences of basic skills were fully mediated by cognitive ability. Thus, the judicious conclusion from our study would be that both basic skills and cognitive ability are important components of training readiness, but that cognitive ability plays a more complex role than a simple antecedent to training success. Our hope is that future research will incorporate the trainability concept so as to provide additional empirical evidence informing whether it is "much more than g."

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[1] A wealth of previous research (see Ree et al., 2003) has shown the ubiquitous influence of general cognitive ability (*g*) in various tests of ability and aptitude. Thus, *g* is portrayed as a force that, to a large extent, underlies most measurements of psychological ability. An example of this view is found in the use of "psychometric *g*" (e.g. Stauffer, Ree, & Carretta, 1996) in which the influence of *g* is taken from scores on the first unrotated principle component. In the specific context of path analysis of observed variables used in the present study, this role of *g* is better modeled as mediation, because the flow of effect from more specific abilities – in our case basic skills – on performance is filtered by varying levels of individuals' *g*. Importantly, this perspective is congruent with definitions of mediation (e.g., Baron & Kenny, 1986), which stipulate that a mediator is a variable that: (1) explains how/why antecedents influence outcomes, (2) partials out direct effects of independent variables on dependant variables, (3) can be either a dependant or independent variable, (4) has a high covariation with the antecedent and outcome variables, and (5) is a generative mechanism thorough which the antecedents influence the outcomes.

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- Selection system design
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- Metric development and data collection
- Advanced data analysis

One specific practice area is analytics, research, and consulting on foreign language and culture in work contexts. In this area, SWA has conducted numerous projects, including language assessment validation and psychometric research; evaluations of language training, training tools, and job aids; language and culture focused needs assessments and job analysis; and advanced analysis of language research data.

Based in Raleigh, NC, and led by Drs. Eric A. Surface and Stephen J. Ward, SWA now employs close to twenty I/O professionals at the masters and PhD levels. SWA professionals are committed to providing clients the best data and analysis with which to make solid data-driven decisions. Taking a scientist-practitioner perspective, SWA professionals conduct model-based, evidence-driven research and consulting to provide the best answers and solutions to enhance our clients' mission and business objectives. SWA has competencies in measurement, data collection, analytics, data modeling, systematic reviews, validation, and evaluation.

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