Research Note 2021-05

Improving the Prediction of Performance in Cyber Training

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14. ABSTRACT *(Maximum 200 words)*:

The U.S. Army Cyber Center of Excellence seeks to maximize the likelihood that Soldiers classified into cyber-related military occupational specialties (MOS) will be successful. Currently, Soldiers must receive passing scores on two measures to be eligible for classification into the 17C occupation (Cyber Operations Specialist). The first is the Skilled Technical composite of the *Armed Services Vocational Aptitude Battery* (ASVAB) and the second is the *Cyber Test*. There is now interest in seeing whether adding a temperament measure would further improve prediction of important Soldier outcomes in this MOS. The *Tailored Adaptive Personality Assessment System* (TAPAS) is a prime candidate to use for this purpose. To investigate the potential of TAPAS to improve the existing system for classifying Soldiers into the 17C MOS, a method for collecting performance criterion data then periodically matching this to predictor and other administrative data was established. Data collection commenced in the summer of 2018; ARI will continue to update the analyses and results as more Soldiers progress through training.

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EXECUTIVE SUMMARY

Research Requirement:

The U.S. Army Cyber Center of Excellence seeks to maximize the likelihood that Soldiers classified into cyber-related military occupational specialties (MOS) will be successful. Currently, Soldiers must receive passing scores on two measures to be eligible for classification into the 17C occupation (Cyber Operations Specialist) at initial entry. The first is the Skilled Technical composite of the *Armed Services Vocational Aptitude Battery* (ASVAB) and the second is the *Cyber Test*. There is now interest in seeing whether adding a temperament measure would further improve prediction of important Soldier outcomes in this MOS.

Procedure:

The *Tailored Adaptive Personality Assessment System* (TAPAS) is a prime candidate to consider as a possible addition to the current classification system. To investigate the potential of TAPAS to improve the existing system for classifying Soldiers into the 17C MOS, a process for collecting performance criterion data then periodically matching this to predictor and other administrative data was established. Data collection to gather Soldier performance ratings from peers and cadre, as well as attitudinal data from Soldiers, commenced in the summer of 2018; ARI will continue to update the analyses and results as more Soldiers progress through training. The school routinely collects grades data and additional performance outcome indicators (e.g., training restarts and attrition) that can also be included in the analysis database.

Findings:

The initial analysis database described here included data on 191 Soldiers, though there were insufficient criterion data to conduct many of the analyses of interest. In this initial examination of the data, the Cyber Test score and course grades were correlated as expected. The TAPAS "Can Do" composite was also significantly correlated with course grades. Of greater interest, however, would be the ability of TAPAS to predict motivational aspects of performance that would be reflected in performance ratings and self-report attitudinal data. While the TAPAS "Will Do" score showed potential for predicting the ALQ Peer Leadership score, sample sizes were too small to examine most of these relationships.

Utilization and Dissemination of Findings:

As more complete and stable results become available, they will be shared with the U.S. Army Cyber Center of Excellence for consideration in adjusting their policy for accepting Soldiers into the 17C MOS.

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Introduction

Project Background

With the recent focus of building and expanding its cyber capabilities, the U.S. Army is increasing its efforts to ensure it has Soldiers who are capable of fighting and defending in the domain of cyberspace. Recent efforts include a reorganization of select career management fields (CMF), expanded requirements for several cyber-related military occupational specialties (MOS), and the creation of additional MOS positions, such as MOS 25D (Cyber Network Defender). The intent of these structural and occupational changes is to ensure that the Army has the necessary manpower to meet the challenges faced in defending the cyberspace domain.

One key to meeting these challenges is effective personnel selection and placement. Being able to fill new roles that require Soldiers with specialized capacities related to the cyber domain requires specialized selection methods. Because the demand for such skills is high, particularly in the military where higher compensation is generally not available, it is useful to select Soldiers with propensity to learn such skills despite having little to no formal cyber training.
Initial work on assessments designed to measure the cyber aptitude of military personnel has been underway over the last several years beginning with the *Cyber Test* developed by the U.S. Air Force. This test, developed with the assistance of cyber/IT subject matter experts (SMEs) from three U.S. military branches, measures the broad areas of network and communications, computer operations, security and compliance, and software programming.

Validation research of this assessment have been promising and the Cyber Test has been shown to provide incremental validity beyond the *Armed Services Vocational Aptitude Battery* (ASVAB) in predicting training school grades in cyber/IT-related courses (Trippe, Moriarty, Russell, Carretta, & Beatty, 2014). The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has expanded an Air Force-developed assessment for operational Army use.

The Cyber Test is currently being used to select Soldiers for initial entry into MOS 35Q (Cryptologic Network Warfare Specialist) and 17C (Cyber Operations Specialist). Validation efforts for other cyber-related MOS are currently underway; it is expected that additional measures will be developed and validated for operational use in the next several years, and that such measures will ultimately provide better performance prediction in cyber-related MOS.

Although not available for the current research, two non-knowledge-based measures are currently under development to supplement the largely knowledge-based Cyber Test. The first of these measures, the *Systems Thinking Assessment*, is aimed at developing novel approaches to measuring systems thinking, which is defined as the ability to understand and manipulate complex systems to attain a specific outcome, and has been identified as a key construct in cyber roles (Boardman & Sauser, 2008). Systems thinking may be a necessary ability to perform cyber roles because these roles involve systems that are complex and dynamic.

The second measure, the *Common Cyber Capabilities Test*, will measure the skills, abilities, and other characteristics that are most predictive of success across various cyber MOS in the Army;

importantly, such skills, abilities, and characteristics are Cyber Test, Systems Thinking Assessment, and Common Cyber Capabilities Test each have a substantial cognitive component. However, it is unlikely that cognitive ability alone determines whether a Soldier will thrive in a cyber-related MOS.

Use of Personality Testing to Increase Validity of Assessments

To help increase the probability of success in cyber-related MOS, research aimed at determining the additional utility of personality tests is needed. In both military and civilian settings, research demonstrates that personality measures predict a number of important outcomes such as job performance and attrition (e.g., Barrick & Mount, 1991; Hough, Eaton, Dunnette, Kamp, & McCloy, 1990). While cognitive abilities and technical skills can predict what individuals are *capable* of doing, personality-based variables tend to be tied to motivational and interpersonal aspects of job performance and are indicative of what they *will* do and how they interact with others (Barrick, Mitchell, & Stewart, 2003; Borman & Motowidlo, 1997).

Particularly when used in conjunction with measures of cognitive ability and technical skill, personality measures can provide incremental validity that can greatly aid in the selection and placement of individuals. This is primarily because personality variables tend to modestly correlate with cognitive ability, and different combinations of personality variables and cognitive ability have been shown to increase accuracy in predicting performance and other important outcomes (Hough & Oswald, 2008).

Recent research has begun to examine the predictive power of narrow dimensions of personality when examining the personality-job performance relationships across different criterion measures and occupations (Hough & Johnson, 2013; Hough & Ones, 2001). This research supports the view that different combinations of personality dimensions vary in their criterion-related validity across different measures of performance and different jobs. For instance, narrow dimensions of conscientiousness have been found to provide incremental validity over broad measures of conscientiousness, and this tends to vary across occupations within the areas of sales, customer service, management, and occupations with specialized skills (Dudley, Orvis, Lebiecki, & Cortina, 2006). An implication of this work is that narrow dimensions of broader personality traits are tied to narrow aspects of specific jobs or job families (Ones & Viswesvaran, 1996).

Despite this, the operational use of personality measures to select and place Soldiers in the U.S. Army has been limited to-date, due, in particular, to concerns about such measures' susceptibility to response distortion (e.g., individuals are motivated to present a positive self-portrait). As a result, traditional enlisted applicant attributes have been mostly limited to cognitive abilities (measured using the ASVAB), medical data, educational attainment, and criminal background information.

An important effort to overcome this concern has been the development of the *Tailored Adaptive Personality Assessment System* (TAPAS; Stark et al., 2014). The TAPAS is an innovative computer-adaptive personality assessment that measures a wide array of personality facets, most of which are derived from the so-called Big Five taxonomy of personality traits. The TAPAS avoids many of the shortcomings of previous personality tests by adopting a forced-choice format that offers no obvious

best answer, making it resistant to faking and intentional distortion (Drasgow, Stark, Chernyshenko, Nye, Hulin, & White, 2012). Additionally, as a computer-adaptive test, it limits administration time and exposure to test content, thus decreasing the potential for test compromise. Because the TAPAS was initially intended for use in the context of military selection the measure includes general personality traits (e.g., intellectual efficiency, order) as well as military-specific dimensions (e.g., physical conditioning, commitment to serve, courage, and team orientation).

Using a Combination of Cyber Test and TAPAS to Improve Selection

Although empirical research on personality in cyber positions is limited, some initial evidence suggests that, in addition to a distinct set of technical skills and cognitive abilities, individuals who are successful in the cyber domain tend to possess a unique set of personality characteristics. For instance, Libicki, Senty, and Pollak (2014) reported on a series of structured interviews with representatives from organizations in the public and private sector and noted that personality characteristics, such as an intense curiosity about how things work, correlate with requirements in cybersecurity jobs.

The Occupational Information Network (O*NET)[1] is another source of information about what characteristics may be necessary for cyber-related jobs. O*NET includes information related to the personal characteristics and preferred work styles associated with effective performance in occupations throughout the U.S. workforce. A review of work styles importance scores (ratings made by SMEs and job incumbents regarding the importance of various work styles) for 10 cyber-related jobs (e.g., systems software engineers; information security analysts) indicates that analytical thinking, attention to detail, dependability, and integrity are particularly important for performing jobs that are cyber-related. These correspond with the TAPAS dimensions of intellectual efficiency, order, responsibility, and virtue. Additionally, information obtained from job analyses of cyber-related MOS indicates these positions generally require individuals to rapidly respond to cyberspace threats, identify system vulnerabilities to cyber attacks, and conduct offensive operations in cyberspace. Besides cognitive abilities, personality dimensions measured by the TAPAS may also be tied to these requirements such as intellectual efficiency, ingenuity, and curiosity. Finally, cyber-related positions in military settings are likely distinct from those in civilian settings and require individual characteristics that relate to adjustment to military life, self-discipline, and adaptability.

Evidence such as this highlights the likelihood that the requirements of any given MOS should be matched not only on ability and technical skill but also with regards to personal characteristics and qualities. Due to the multidimensional nature of job performance (e.g. task performance, citizenship behaviors, counterproductive behavior), personality measures have been shown to predict specific aspects of job performance and other important outcomes (e.g. attrition) that are not related to cognitive ability (Barrick et al., 2003; Campbell & Knapp, 2001; Hogan & Holland, 2003). In the case of cyber-related MOS, personality measurement has the potential to augment the predictive ability of current selection tests for cyber-related positions, which currently consist of a combination of ASVAB and Cyber Test scores.

[1] See ONETonline.org

Findings investigating the inclusion of the TAPAS in personnel selection in other areas in the Army have provided evidence that this work could be very valuable, particularly in predicting motivational aspects of performance (Knapp & Kirkendall, 2020). Initial validation work shows similar patterns with a small sample of data from 35-series MOS (intelligence) (Trippe, Canali, Wind, & Koch, 2019).

Despite the promise of using personality assessments to enhance the predictive validity of cognitive tests, the effectiveness of using TAPAS in conjunction with the Cyber Test is not currently known. It is routinely administered, but not used to classify Soldiers into cyber MOS. Validation research is necessary to determine its utility for the purposes of classification into cyber-related MOS. The goal would be to identify individuals that not only are able to fulfill the technical requirements of cyber positions but also possess the necessary characteristics and personal qualities that are unique to success in this increasingly important area.

The identification and development of TAPAS composites that are MOS-specific has several potential benefits. One is that it could improve the effectiveness of MOS assignment by improving person-job fit and decreasing the number of training failures. Another benefit is that it could shorten test administration, particularly for the purposes of reclassification, by identifying a shorter set of TAPAS dimensions that can be assessed for the purposes of specific MOS. As a first step in this research, ARI is working with MOS 17C, as the U.S. Army Cyber Center of Excellence (Cyber COE) is particularly interested in improving performance outcomes in that MOS.

Summary of Approach

MOS 17C is a fairly new MOS and still has a relatively small number of job incumbents. Soldiers graduating from initial military training (IMT), as opposed to widely dispersed Soldiers in units, were thus identified as the ideal population for this research. Our goal was to set up ongoing data collections to eventually obtain reasonably large numbers of cases on which to evaluate predictors.

To do this, we identified and developed outcome measures to evaluate the predictive validity of the TAPAS. In creating these measures, we had a particular focus on motivational aspects of performance. Thus, we developed 17C-specific performance rating scales. Additionally, we included both can-do and will-do measures to obtain a better picture of how all the predictors for which we have data (ASVAB, Cyber Test, and TAPAS) can work together.

To achieve our goal of developing an ongoing data collection system, we first implemented a stand-alone criterion data collection in the summer of 2018. However, we determined we could combine our research with ongoing Army-wide data collections for another research project (*Validation of Accessions Screening Tools*; VAST) in which we are gathering data from trainees and peers. Instructors' ratings are still collected as a stand-alone activity. We are also obtaining administrative and predictor data from Army records.

The predictor and criterion (performance outcome) measures are described next. At present, data collection is ongoing. An initial database has been compiled. The sample size is small, however, so only descriptive and correlational analyses are reported here. We describe inferential analyses that we recommend be conducted once the sample size becomes large enough to support them.

Predictor Measures

Two of the predictor measures in this research – the Cyber Test and TAPAS – have already been introduced. This section provides further information about those two assessments as well as the ASVAB.

Armed Services Vocational Aptitude Battery

The ASVAB is administered to all applicants for enlistment into U.S. military service. There is considerable evidence demonstrating that ASVAB-based scores predict performance in military training, particularly with regard to performance on job knowledge tests (e.g., Ingerick, Cheng, & Allen, 2009; Hughes, 2020; Oppler, McCloy, & Peterson, 1992; Russell, Le, & Putka, 2007). The ASVAB comprises 10 multiple-choice subtests:

- General Science (GS)
- Arithmetic Reasoning (AR)
- Word Knowledge (WK)
- Paragraph Comprehension (PC)
- Mathematics Knowledge (MK)
- Electronics Information (EI)
- Auto Information (AI)
- Shop Information (SI)
- Mechanical Comprehension (MC)
- Assembling Objects (AO)

Word Knowledge and Paragraph Comprehension are combined to form the Verbal Expression (VE) composite. Subtests are further combined into various composite scores for selection and classification of enlisted personnel. The *Armed Forces Qualification Test* (AFQT) combines the Verbal Expression, Arithmetic Reasoning, and Math Knowledge subscores and is used as a selection screen. The Army classifies enlistees into MOS based in part on nine aptitude area scores computed from the ASVAB. Entry into the 17C MOS requires a minimum score of 112 on the *Skilled Technical* (ST) and 110 on the *General Technical* (GT) aptitude areas. The Skilled Technical score is computed using General Science, Verbal Expression, Math Knowledge, and Mechanical Comprehension subscores. The GT score is computed using the Verbal Expression and Arithmetic Reasoning subscores.

Cyber Test

A panel of measurement experts convened by the Department of Defense (DoD) in 2005 offered 22 recommendations related to the ASVAB (Drasgow, Embretson, Kyllonen, & Schmitt, 2006). One of these was to consider adding a subtest related to information/communications technology literacy. The Air Force took the lead in developing such a test (Trippe et al., 2014).

There are currently two 40-item operational *Cyber Test* forms. Table 1 shows the distribution of content on those forms. All items use a 4-option multiple-choice format.

Although the Cyber Test has not been added to the ASVAB itself, it is administered during accessions on the ASVAB platform. The 17C MOS proponent (Cyber Center of Excellence) began requiring applicants exceed Cyber Test cut-score as a requirement for entry into 17C primarily as a result of positive criterion-related validation evidence for two related MOS – Information Systems Operator-Analyst (25B) and Nodal Network Systems Operator-Maintainer

(25N). This work involved prediction of performance in training and is documented in Trippe et al. (2016).

Table 1. Content Distribution of Cyber Test Forms

	Form A		Form B	
Content/Subcontent Area	N Items	Percent	N Items	Percent
Networking and Communications	7	24 % Blueprint =27%	7	24% Blueprint =27%
Network Config. & Maint.	*4*		*4*	
Telecommunications	*3*		*3*	
Computer Operations	12	41% Blueprint = 36%	12	41% Blueprint = 36%
PC Config. & Maint.	*6*		*5*	
Using IT Tools and Software	*6*		*7*	
Security and Compliance	7	24% Blueprint = 23%	7	24% Blueprint = 23%
System Security	*4*		*3*	
Offensive Methods	*3*		*4*	
Software Prog. and Web Dev.	3	10% Blueprint = 14%	3	10% Blueprint = 14%
TOTAL	29	100%	29	100%

Note. Reprinted from Trippe and Russell (2011). Percent is percent of test, whereas Blueprint is the percentage prescribed by the initial test blueprint.

Tailored Adaptive Personality Assessment System (TAPAS)

TAPAS was developed by the Drasgow Consulting Group under the Army's Small Business Innovative Research program (Drasgow et al., 2012). As previously noted, TAPAS measures various temperament characteristics considered likely to predict motivational aspects of job performance. The TAPAS versions administered to Army applicants in the present research assess the subset of facets listed in Table 2 (Stark, Chernyshenko, Nye, & Drasgow, 2018). Each of the three test forms administered for the last several years measures 13 facets, some of which are unique to one or two of the three forms.

The TAPAS algorithm generates pairs of statements, with respondents directed to indicate which statement is most like them. The pairs are created by identifying statements from two facet pools that are equivalent in terms of their social desirability. The TAPAS algorithm ensures that each respondent sees a sufficient number of statements to reliably calculate scores on each of the 13 facets.

For selection purposes, the Army has developed three TAPAS composite scores – Can Do, Will Do, and Adaptation. Evidence related to the power of these scores to predict performance in training and in the field across MOS has been gathered systematically since 2010 (see Knapp & Kirkendall, 2020 for the most recently published report of these findings). Currently, however, TAPAS scores are not being used to screen for enlistment.

Table 2. TAPAS Facets (Pre-Enlistment Forms Administered 2013 - 2019)

Facet	Form		
	13D-CAT v9	13D-CAT v10	13D-CAT v11
Achievement	X	X	X
Attention Seeking			X
Commitment to Serve	X		X
Cooperation	X		
Courage		X	
Dominance	X	X	X
Even Tempered	X	X	X
Intellectual Efficiency	X	X	X
Non-Delinquency		X	
Optimism	X	X	X
Order	X	X	X
Physical Conditioning	X	X	X
Responsibility	X		
Selflessness	X	X	X
Situational Awareness		X	
Sociability	X	X	X
Team Orientation			X
Tolerance	X	X	X

An important goal of the present research is to determine whether one or more TAPAS composites can identify enlisted Soldiers most likely to succeed in 17C training.

Criterion Measures

In this section, we describe the anticipated measures needed to address the previously stated problem: determine how the aforementioned predictors could best be used to classify Soldiers into the 17C MOS. At this point in the research, however, sufficient data on most of these criterion measures are not yet available for analysis.

Army Life Questionnaire

The *Army Life Questionnaire* (ALQ) is used to gather attitudinal data and self-report administrative information. The measure originated in ARI's Select21 research program (Knapp, Sager, Tremble, 2005) although it had origins in the Army's Project A (Campbell & Knapp, 2001). The ALQ was recently revised (Nesbitt, Salmon, & Kirkendall, 2020).

Table 3 shows the 13 ALQ scales, each of which is comprised of 3 to 9 items. Of primary interest in the present research is the ALQ's three composite scores, which are based on the following scales:

- *Commitment and Fit* – Affective Commitment, Army Fit, MOS Fit

- *Peer Leadership* – Motivation to Lead (Affective, Noncalculative, Social Normative), Organizational Citizenship Behavior/Leadership
- *Retention Cognitions* – Army Career Intentions, Army Reenlistment Intentions

The reliability estimates for the scale-level and composite scores shown in Table 3 were based on over 60,000 cases in the VAST research. Estimates for the three composite scores of interest in the present research are acceptable, ranging from .81 to .92.

Table 3. Army Life Questionnaire Scale Reliability Estimates

Variable	IMT		In-Unit	
	Alpha	Number Scales/Items	Alpha	Number Scales/Items
Composites				
Commitment and Fit [a]	.81	3	.82	3
Peer Leadership [a]	.82	4	.84	4
Retention Cognitions	.92	2	.94	2
Likert Scales				
Affective Commitment	.80	3	.80	3
Army Fit	.77	4	.79	4
Army Life Adjustment	.79	4	—	—
Counterproductive Soldier Behavior	.85	9	.79	9
Deployment Satisfaction	—	—	.81	4
MOS Fit	.86	5	.88	5
MOS Satisfaction	—	—	.84	5
Motivation to Lead - Affective	.84	3	.84	3
Motivation to Lead - Noncalculative	.78	3	.78	3
Motivation to Lead - Social Normative	.77	3	.78	3
Organizational Citizenship Behavior/Leadership	.87	8	.87	8
Resilience	.81	7	.79	7
Work/Life Balance	.87	5	.86	5

Note. Reprinted from Nesbitt, Salmon, and Kirkendall (2020). Army Career Intentions and Reenlistment Intentions are single-item measures, and therefore alpha is not reported for these variables.

[a] Alphas reflect the average of the composite scale alphas.

Army-Wide Performance Ratings

Performance rating scales (PRS) suitable for Soldiers in any MOS training (i.e., Army-wide PRS) are used to collect peer ratings. These rating scales were developed primarily by ARI researchers and are described in detail in Knapp, Salmon, Kirkendall, and Burgoyne (2020). Table 4 shows the rating dimensions and sample behaviors. Figure 1 illustrates the rating scale format with two dimensions. Data on these rating scales are only collected from peer raters.

Table 4. Army-Wide Performance Rating Scale Dimensions and Example Behaviors

Scale	Example Behaviors
Effort and Discipline	• Puts forth individual effort in study, practice, and other training activities • Shows respect in word and action towards superiors • Obeys instructions, rules, and regulations • Maintains self, uniforms, living areas, and barracks to Army standards
Working Effectively with other Soldiers	• Respects, assists, and cooperates with fellow Soldiers • Treats all Soldiers with courtesy and respect, regardless of gender, race, ethnicity, ability, or background differences • Communicates ideas and information clearly and directly
Physical Fitness	• Maintains and enhances physical readiness • Performs required physical tasks
MOS Qualification Knowledge and Skill	• Learns and demonstrates AIT/OSUT knowledge and skills required for MOS qualification • Effectively applies training, rules, and strategies to solve problems
Resilience and Adjustment	• Persists in carrying out difficult tasks, even in stressful circumstances • Remains calm during high-pressure situations • Bounces back after facing a difficult situation or failure • Adjusts well to life in the Army
Counterproductive Soldier Behaviors	• Takes shortcuts that may be harmful • Takes unauthorized breaks • Leaves a mess for someone else to clean up
Going Above and Beyond	• Notices when a fellow Soldier is falling behind and offers assistance • Offers to help fellow Soldiers struggling to learn training material and skills • Goes out of the way to give another Soldier encouragement or express appreciation • Spends free time learning about procedures, equipment, etc.
Overall Performance	Instructions: Considering your evaluation of your peers on the dimensions important to being a successful Soldier, please rate the overall performance of each Soldier.

Note. Reprinted from Nesbitt, Salmon, Kirkendall, and Burgoyne (2020).

A. Effort and Discipline				
Example behaviors: • Puts forth individual effort in study, practice, and other training activities • Shows respect in word and action towards superiors • Obeys instructions, rules, and regulations • Maintains self, uniforms, living areas, and barracks to Army standards				
1	2	3	4	5
Much less than other Soldiers in my unit	Somewhat less than other Soldiers in my unit	About as much as other Soldiers in my unit	Somewhat more than other Soldiers in my unit	Much more than other Soldiers in my unit
B. Counterproductive Soldier Behaviors				
Example behaviors: • Takes shortcuts that may be harmful • Takes unauthorized breaks • Leaves a mess for someone else to clean up				
1	2	3	4	5
Much less often than other Soldiers in my unit	Somewhat less often than other Soldiers in my unit	About as often as other Soldiers in my unit	Somewhat more often than other Soldiers in my unit	Much more often than other Soldiers in my unit

Figure 1. Sample Army-wide performance rating scales.

The Army-wide PRS score is an average of seven of the eight individual ratings. While none of the interrater reliability estimates for the individual scales were very strong (see Table 5), estimated reliability of the negatively worded Counterproductive Soldier Behaviors dimension was particularly low. Therefore, it is not included in the overall composite score.

Table 5. Army-Wide Performance Rating Scale Interrater Reliability Estimates

IMT	$G(q,k)$	k	n_{Ratees}	n_{Raters}
Effort and Discipline	.46	2.16	8,969	8,238
Working Effectively with Other Soldiers	.41	2.18	8,987	8,268
Physical Fitness	.60	2.14	8,959	8,199
MOS Qualification Knowledge & Skill	.45	2.15	8,971	8,240
Resilience and Adjustment	.42	2.14	8,972	8,209
Counterproductive Soldier Behaviors	.25	2.10	8,909	7,990
Going Above and Beyond	.39	2.14	8,954	8,178
Overall Performance Rating	.50	2.18	8,984	8,255

Note. Reprinted from Knapp, Salmon, Kirkendall, and Burgoyne (2020).

MOS-Specific Performance Ratings

To develop performance rating scales specific to 17C Soldiers, we modified scales that had been created previously for a related MOS (35Q). This involved a review of course materials for 35Q followed by meetings with SMEs from that MOS. Approximately 15 instructors and advanced students in the 17C MOS identified changes needed to align the scale with the actual 17C duties.

Based on this review, one rating dimension was added, one was divided into two separate rating dimensions, and slight wording changes were made to others.

The resulting 11 dimensions are listed in Table 6. Each is rated on the 5-point scale shown in Figure 2. Appendix A shows the full set of rating dimensions with descriptions.

Table 6. 17C Performance Rating Scale Dimensions

Windows/UNIX Fundamentals and Fundamentals of Computer Science, Organization, and Architecture
Demonstrate Knowledge of Networking Concepts and Protocols
Demonstrate Fluency with Windows Operating System
Demonstrate Fluency with UNIX Operating System
Demonstrate Knowledge of Programming Concepts
Demonstrate Knowledge of Advanced Networking Components, Router Security, and Protocol Analysis
Demonstrate Knowledge of Wireless Networking Technologies
Conduct Exploitation Operations
Perform Computer Network Defense and Analysis
Conduct Forensics and Malware Analysis
Demonstrate Knowledge of Cyberspace Operations

As previously noted, the peer ratings data (both Army-wide and 17C-specific) are collected as part of the VAST research project. The VAST data collection protocol requires cadre to provide trainees with a paper copy of their class roster. The online survey instructs trainees to find their name on the class roster, and then rate the five Soldiers listed immediately below their own name. Before rating these classmates, they complete a "familiarity" rating to ensure they have had sufficient opportunity to observe the individuals they are being asked to rate.

Among the Weakest (in the bottom 20% of Soldiers)	**Below Average** (in the bottom 40% of Soldiers)	**Average** (better than the bottom 40% of Soldiers, but not as good as the top 40%)	**Above Average** (in the top 40% of Soldiers)	**Among the Strongest** (in the top 20% of Soldiers)	***Cannot Rate***
1	**2**	**3**	**4**	**5**	***n/a***

Figure 2. 17C performance rating scale anchors.

The rating scales administered to peers include only the 11 17C-specific behavioral dimensions. The cadre rating scales also include a Part II section that has 16 items that are not MOS-specific (see Appendix B), but which will be evaluated as potential outcome measures. Note also that, while the cadre rating scales do not ask for familiarity ratings, they do ask raters to indicate which of the 11 dimensions they are able to evaluate.

Administrative Measures

Training Restarts

Training completion status information is obtained from the Army Training Requirements and Resources System (ATRRS) database. Training Restarts is a dichotomous variable indicating whether the trainee was required to restart training at least once.

Attrition

Separation from the Army before the end of an enlistment contract period may signal misfit with the Army and/or a given MOS. For the present research, we are interested in attrition that occurs within six months of enlistment. For analyses using this variable, trainees who left the Army for reasons outside of their or the Army's control (e.g., serious injury) are excluded from analysis.

Course Grades

We used course grade information obtained from the school to calculate three scores for the VAST database: (1) the final grade for the first section of the curriculum, (2) the final grade for the second section of the curriculum, and (3) the overall final grade across all courses. The first section of the curriculum consists of BASH, PowerShell, and Python courses, and the second includes Windows, Linux, and Networking courses. The overall grade consists of the previous two mentioned final grades, along with a course in cyber protection, offensive cyber operations, and a capstone class. When an individual is required to retake a course, we used his or her first grade in calculating the score.[2] If the first grade was unavailable (e.g., for those recycling before 2018), the corresponding score was set to missing.

Database Development

We expect this ongoing research will include multiple opportunities to capture and merge data from a variety of sources to create or update the integrated 17C analysis database. The primary source of data comes from the VAST contract, which produces biannual updates of its large-scale longitudinal database. The 17C database prepared for purposes of the present report was created using data extracted from the VAST Cycle 19 database (Knapp, Kirkendall, & Nesbitt, 2020). Cycle 19 includes predictor data collected through the end of 2018 and criterion data collected through May 2019. The VAST database provided all the variables except for course grades. The grades data provided by the Cyber school were matched to the VAST database using Soldier name. Note that the resulting 17C database does not include instructor ratings, which will be a third source of data to integrate into future 17C database updates.

[2] When the schoolhouse calculates grades, they use the retake grade rather than the original grade.

Data Analysis

Sample

Table 7 provides a general overview of the characteristics of the initial 17C analysis sample. Though sample sizes for specific analyses are smaller, the total sample size is a fairly healthy 191. The sample is largely male (80.6%), white (73.8%), and non-Hispanic (76.4%).

Table 7. Sample Description

Characteristic	*n*	%
Gender		
Female	9	4.7
Male	154	80.6
Missing	28	14.7
Race		
African American	20	10.5
American Indian	0	0
Asian	9	4.7
Hawaiian/Pacific Islander	0	0
Caucasian	141	73.8
Multiple	0	0
Missing	21	11
Ethnicity		
Hispanic/Latino	24	12.6
Not Hispanic	146	76.4
Declined to Answer/Missing	21	11
Total *n*	191	100

Descriptive Statistics

Table 8 shows descriptive statistics for the predictor scores and Table 9 shows their intercorrelations. Theoretically, all Soldiers in the sample would have complete predictor data records. The VAST database is created by matching records from various data sources using Soldier name and date of birth. This process leads to some loss of data given inconsistencies between data sources in capturing these variables.

Table 8. Descriptive Statistics for Predictor Measures

Variable	*n*	Mean	*SD*	Min	Max
ST Score	170	125.18	8.90	99.00	150.00
Cyber Test Score	139	66.12	4.03	53.00	77.00
TAPAS Can Do	158	121.09	18.64	71.05	171.31
TAPAS Will Do	159	94.70	21.92	52.68	149.60
TAPAS Adaptation	158	103.55	18.47	55.72	147.55

Note. ST Score = ASVAB Skilled Technical Composite score.

Table 9. Predictor Score Intercorrelations

	ST Score	Cyber Test	TAPAS-Can Do	TAPAS-Will Do	TAPAS-Adapt
ST Score	1				
Cyber Test	.34** (139)	1			
TAPAS Can Do	.29** (158)	.13 (136)	1		
TAPAS Will Do	.01 (159)	-.06 (136)	.05 (158)	1	
TAPAS Adaptation	.16* (158)	.02 (136)	.35** (158)	.49** (158)	1

Note. Valid pairwise *n* is reported parenthetically below each correlation coefficient. ST Score = ASVAB Skilled Technical Composite score.
* $p < .05$ (two-tailed). ** $p < .01$ (two-tailed).

In the full applicant sample, which includes over 1 million cases, average TAPAS scores are roughly 100. In contrast, the average TAPAS Can Do score for this 17C sample is relatively high (mean = 121.09, *SD* = 18.64) and the TAPAS Will Do score is somewhat low (mean = 94.70, *SD* = 21.92).

Table 10 provides descriptive statistics for the criterion scores included in this initial analysis database. Part 1 and Part 2 grades are the only continuous criteria with sample sizes over 100. We included ALQ Peer Leadership and the Army-wide peer performance ratings in our analyses, but their sample sizes are too low to yield stable results. Training Restarts (a dichotomous criterion) has complete data, but the base rate is too low to analyze at this time. For similar reasons, we did not include attrition in this initial database.

Table 10. Descriptive Statistics for Criterion Measures

Variable	*n*	Mean	*SD*	Min	Max
Army Life Questionnaire					
Commitment and Fit	2	3.86	1.14	3.06	4.67
Peer Leadership	56	3.23	0.45	1.92	3.97
Retention Cognitions	2	3.60	0.22	3.44	3.75
Administrative Criteria					
Training Restarts	191	0.04	0.2	0	1.00
Part 1 Grade	140	92.45	8.06	56.63	100.00
Part 2 Grade	110	86.29	6.01	71.80	100.00
Final Grade	57	91.30	4.25	81.17	98.60
Peer Performance Ratings					
Army-wide scales	48	3.55	0.41	2.39	4.29

17C-specific scales	17	4.15	0.56	3.18	5.00

Note. Training Restarts coded as 1 = yes, 0 = no.

Criterion score intercorrelations are shown in Table 11. Note the dramatic drop in sample size for Final Grade (n = 57) from the Part 1 *(*n = 140) and Part 2 (n = 110) grades, as well as the near perfect (r = .95) correlation between Part 2 grade and Final Grade. We suspect the Final Grade is artificially constrained by the fact that it can only be calculated for Soldiers who have successfully completed training, an issue exacerbated by the unavailability of first pass Part 1 grades for some of this sample.

Table 11. Criterion Score Intercorrelations

	P1 Grade	P2 Grade	Final Grade	Peer Leader	AW Ratings
P1 Grade	1				
P2 Grade	.54** (91)	1			
Final Grade	.73** (57)	.95** (57)	1		
ALQ Peer Leadership	-.08 (36)	.12 (36)	-.07 (36)	1	
Army-Wide Performance Ratings	.17 (32)	.01 (32)	-.03 (32)	.08 (40)	1

Note. Valid pairwise n is reported parenthetically below each correlation coefficient. ALQ Commitment and Fit, ALQ Retention Cognition, and 17C performance rating composites are excluded due to insufficient sample size.
** $p < .01$ (two-tailed).

Validity Estimates

Table 12 shows bivariate correlations among the predictor and criterion scores. Although we report correlations for five criterion scores, the Part 1 and Part 2 grades are the only criteria for which there are sufficient data to yield anything other than suggestive results. As one would expect, the correlations between the Cyber Test score and both course grades (Part 1 and Part 2) are statistically significant. The TAPAS Can Do composite is also significantly correlated with course grades. The ALQ Peer Leadership and the Army-wide peer ratings score are negatively correlated with the ST line score. A larger sample size is needed to determine if these relationships remain consistent. The TAPAS Will Do score shows potential for predicting ALQ Peer Leadership, which aligns with previous research.

Table 12. Predictor-Criterion Score Intercorrelations

	Part 1 Grade	Part 2 Grade	Final Grade	Peer Leader	Army-wide Ratings
ST Score	.21* (120)	.16 (98)	.26 (52)	-.33* (56)	-.22 (48)
Cyber Test	.20* (100)	.35** (78)	.31 (36)	-.05 (35)	-.08 (34)
TAPAS Can Do	.23* (109)	.25* (88)	.39** (45)	-.13 (50)	-.16 (44)
TAPAS Will Do	-.02 (110)	.05 (89)	-.07 (46)	.28* (51)	-.06 (44)
TAPAS Adaptation	.07 (109)	.19 (88)	.09 (45)	-.08 (50)	-.04 (44)

Note. Valid pairwise *n* is reported parenthetically below each correlation coefficient. ALQ Commitment and Fit, ALQ Retention Cognition, and 17C performance rating composites are excluded due to insufficient sample size. ST Score = ASVAB Skilled Technical Composite score. * $p < .05$ (two-tailed). ** $p < .01$ (two-tailed).

Future Data Analysis Plan

When the 17C longitudinal sample gets significantly larger, it will be possible to explore bivariate relationships among the research variables with more confidence. It may also become possible to examine incremental validity of both existing and newly configured TAPAS composite scores for screening into the 17C MOS. In anticipation of this occurring, we suggest the following plan of analysis.

Alternative TAPAS Composite Score Development

Our recommended analysis plan includes computing bivariate correlations between each current predictor used to classify Soldiers into the 17C MOS (ST score and Cyber Test score) and the TAPAS facet-level scores with the criterion measures. Review of these correlations will suggest which TAPAS facet scores might be combined to create a composite score that would be effective for helping to classify individuals into the 17C MOS when used in combination with ST and the Cyber Test. As the sample size grows, it should be feasible to examine differential impact of alternative TAPAS composite scores on gender and race/ethnic subgroups. Bear in mind, however, that not all forms of the TAPAS include the same facets, so it may take a significant amount of time to get sufficient data to fully evaluate alternative composite scores that include certain promising facets.

Incremental Validity Estimates

To get a better idea of the extent to which existing or new TAPAS composite scores could improve upon the predictive power of the current screening system, potential alternative composites could be evaluated by calculating the amount of incremental validity provided over ST and the Cyber Test. To do this, we recommend estimating a regression model for each

criterion variable with AFQT, ST, and Cyber Test scores as predictors. After doing this, the TAPAS composite can be added to the model to determine the magnitude of the change in *R* and, more specifically, whether adding the additional variables explains significantly more variance in the criteria. The analyses could follow closely the approach used in prior VAST research (Hughes, 2020).

Alternative TAPAS composite scores could also be evaluated using the Training Restarts and attrition criteria, but a different analytical method is required. Our suggested analysis plan would again draw upon precedence established in related ARI research, which uses an estimated odds ratios approach. Further detail about both approaches can be found in Hughes (2020).

Conclusion

To determine if TAPAS could be used to improve the identification of those who will be most successful in the 17C MOS, ARI has established an ongoing data collection activity and associated plans for analyzing the resulting integrated database. This is currently a small volume MOS, so we anticipate that there will be multiple rounds of database updating and analysis to generate more stable estimates of the bivariate relationships among all the research variables. Even more data will be required to develop and evaluate alternative TAPAS composite scores that would demonstrate meaningful incremental validity over the current classification criteria – the ASVAB Skilled Technical composite and the Cyber Test.

In this initial examination of the data, the Cyber Test score and both course grades (Part 1 and Part 2) were correlated, as expected. The TAPAS Can Do composite was also significantly correlated with course grades. The TAPAS Will Do score showed potential for predicting the ALQ Peer Leadership score.

As this research continues, it may be possible to improve the amount and quality of the grades data through additional coordination with schoolhouse personnel. Moreover, once instructor ratings are incorporated into the database, it will be important to examine their psychometric quality. Of particular interest will be whether the information in Part II of the ratings instrument will be useful to incorporate into one or more supplemental ratings-based criterion scores.

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APPENDIX A

17C PERFORMANCE RATING SCALES (PEER AND SELF)

1. Read the whole description.
2. Base your rating on what you have seen. Use Not Observed/Cannot Rate when necessary.
3. Reflect on Soldiers' typical performance including strengths and weaknesses.

Consider the Soldier's typical performance over the time you have observed him/her at AIT/OSUT. Indicate how well the Soldier performs ***relative to other Soldiers that you have observed*** using the rating scale shown below. **Click on the radio button** that best reflects the Soldier's performance. If you have not had adequate opportunity to observe the Soldier perform a duty, click on the button for "Cannot Rate." Ratings are for research only and will not affect you or the rated Soldier.

A. Windows/UNIX Fundamentals and Fundamentals of Computer Science, Organization, and Architecture

- Utilizes basic Windows/UNIX administration and network commands
- Demonstrates understanding of basic Windows/UNIX file structure
- Conducts Windows/UNIX networking administration
- Successfully makes calculations from hex, binary, and octal to other numeric forms
- Successfully diagrams a circuit of logic gates as a Boolean expression and uses its truth table to derive an input/output table
- Creates simple instructions with the fetch-execute instruction cycle

B. Demonstrate Knowledge of Networking Concepts and Protocols

- Successfully subnets and supernets a provided network
- Identifies devices, protocols, services, and usage in a network
- Identifies and utilizes the appropriate tools to analyze data on a network
- Demonstrates understanding of tunneling methodologies, protocols, and well known ports
- Can identify all layers and associated devices for the Open Systems
- Interconnect (OSI) and TCP/IP reference models

Among the Weakest (in the bottom 20% of Soldiers)	**Below Average** (in the bottom 40% of Soldiers)	**Average** (better than the bottom 40% of Soldiers, but not as good as the top 40%)	**Above Average** (in the top 40% of Soldiers)	**Among the Strongest** (in the top 20% of Soldiers)	**Cannot Rate**
○	○	○	○	○	○

D. Demonstrate Fluency with UNIX Operating System

- Demonstrates an understanding of UNIX architecture and the boot process
- Demonstrates an understanding of file system fundamentals, navigation, and how data is accessed
- Configures software to allow file system interaction with other networking devices
- Analyzes the security posture of the operating system
- Manages user accounts on UNIX
- Identifies type of UNIX system
- Demonstrates an understanding of command line interfaces (CLI)

E. Demonstrate Knowledge of Programming Concepts

- Demonstrates ability to read and identify basic programming functions
- Creates, modifies, and interprets basic scripts (e.g., UNIX Bash shell, Windows Batch shell, C++, Python, Powershell)
- Creates, modifies, and interprets basic HTML pages
- Employs critical thinking, programming logic, and problem-solving skills
- Develops efficient script that allows ease of management

F. Demonstrate Knowledge of Advanced Networking Components, Router Security, and Protocol Analysis

- Demonstrates knowledge of network architecture on physical networks
- Demonstrates knowledge of network architecture on virtual machines
- Analyzes Cisco router configuration files to determine router strengths and weaknesses and its bordering networks
- Performs bit-by-bit analysis of protocols using common packet analysis tools to identify operating systems and software
- Analyzes network traffic for use in reconstructing and mapping of networks

Among the Weakest (in the bottom 20% of Soldiers)	**Below Average** (in the bottom 40% of Soldiers)	**Average** (better than the bottom 40% of Soldiers, but not as good as the top 40%)	**Above Average** (in the top 40% of Soldiers)	**Among the Strongest** (in the top 20% of Soldiers)	**Cannot Rate**
○	○	○	○	○	○

G. Demonstrate Knowledge of Wireless Networking Technologies

- Uses wireless networking standards and protocols to conduct wireless targeting, conduct wireless surveys, and capture network traffic
- Analyzes data derived from wireless packet capture for use in reconstructing and mapping of wireless networks from unknown encrypted capture files (or, performs unknown encrypted network mapping)
- Demonstrates knowledge of wireless networking devices and their functions
- Demonstrates knowledge of 802.11 protocols

H. Conduct Exploitation Operations

- Uses differing tools and techniques for foot printing of target networks
- Enumerates a target network and network devices
- Gains access and exploits devices on target networks
- Maintains situational awareness
- Covers tracks on exploited devices
- Creates and installs persistent backdoors on exploited devices

I. Perform Computer Network Defense and Analysis

- Hardens systems to defend against exploitation and attack
- Demonstrates an understanding of Information Assurance
- Analyzes device and network vulnerabilities
- Demonstrates knowledge of security reporting organizations, reporting vehicles, and reports
- Identifies security hardware and software products
- Sets up and manages access control lists (ACLs)

J. Conduct Forensics and Malware Analysis

- Demonstrates knowledge of incident response, to include demonstrating fluency with the chain of custody process
- Performs digital forensics acquisition, analysis, and documentation
- Performs basic malware analysis
- Uses packet analysis to identify types of attacks and malicious intent

Among the Weakest (in the bottom 20% of Soldiers)	**Below Average** (in the bottom 40% of Soldiers)	**Average** (better than the bottom 40% of Soldiers, but not as good as the top 40%)	**Above Average** (in the top 40% of Soldiers)	**Among the Strongest** (in the top 20% of Soldiers)	**Cannot Rate**
O	O	O	O	O	O

K. Demonstrate Knowledge of Cyberspace Operations

- Demonstrates knowledge of USCC operational structure
- Demonstrates knowledge of cyberspace operation mission subsets
- Demonstrates situational awareness of cyberspace capabilities (OCO, DCO, DODIN, EW)
- Demonstrates knowledge of cyberspace operational terminology
- Demonstrates knowledge of proper handling of classified information

Among the Weakest (in the bottom 20% of Soldiers)	**Below Average** (in the bottom 40% of Soldiers)	**Average** (better than the bottom 40% of Soldiers, but not as good as the top 40%)	**Above Average** (in the top 40% of Soldiers)	**Among the Strongest** (in the top 20% of Soldiers)	**Cannot Rate**
O	O	O	O	O	O

APPENDIX B

PART II RATINGS INCLUDED ON INSTRUCTOR PERFORMANCE RATING SCALES

1. Performance relative to peer group (i.e., other students)

   - Among the weakest (in the bottom 20% of Soldiers)
   - Below average (in the bottom 40% of Soldiers)
   - Average (better that the bottom 40% but not as good as the top 40%)
   - Above average (in the top 40% of Soldiers)
   - Among the strongest (in the top 20% of Soldiers)
   - Cannot rate

How much do you agree with the following statements?

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree
- Cannot say/Not applicable

2. In general, _____ struggled to meet the requirements of training.

3. _____ was not prepared for the challenges of training in the Army.

4. _____ would be better suited for another MOS.

5. _____ is the right person for the type of work that this MOS requires.

6. The Army is a good match for _____.

7. _____ has a tendency to take charge in most groups or teams.

Compared to other Soldiers in the class, how often does…

- Far less often
- Less often
- About as often
- More often
- Far more often
- Cannot say/Not applicable

8. _____ demonstrate concern about the image or reputation of their class?

9. _____ give another Soldier the “silent treatment?”

10. _____ go out of the way to encourage or praise another Soldier in training?

11. _____ keep the class focused on its goals and objectives?

12. _____ openly question the decisions, intent, or wisdom of cadre?

13. _____ seek out a challenging assignment that is above and beyond regular duties?

14. _____ take initiative to practice or develop skills outside of the classroom or programmed exercises?

15. _____ volunteer to help another Soldier practice or learn skills during, or outside of, programmed instruction?

16. _____ waste time in training?