Identifying a Psychometric Profile for Vulnerability Assessment Professionals

Talent Identification to Support Career Assessment

Martha Crosby, Ph.D. University of Hawaii - Manoa
Curtis Ikehara, Ph.D. Applied Computer Electronics Custom Design
Gregory P.M. Neidert, Ph.D, Professor Emeritus, Arizona State University
Morgan A. Zantua, M.A. University of Washington CIAC, Director Professional Workforce Development

ABSTRACT

An inter-collegiate research team completed initial research analysis of 119 professional cybersecurity workers from government and industry to identify talent profiles aligned with four roles within the Protect and Defend (PD) NICE Workforce Framework: Cybersecurity Defense Analyst, Cybersecurity Defense Infrastructure Responder, Cybersecurity Incident Responder and Cybersecurity Vulnerability Assessment Analyst. Anonymized data collected from multiple organizations with performance assessments to build statistically validated psychometric profiles of high potential PD cybersecurity candidates. Data collection was obtained using the World of Work Inventory (WOWI) a multi-dimensional on-line career assessment which measures six aptitude and achievement dimensions in the Career Training Potentials, twelve work-style preferences in the Job Satisfaction Indicators and task-relevant preferences related to seventeen career families in the Career Interest Activities. Anonymized, aggregated ranked data described profiles of existing high performing candidates working in the field. Utilization of a methodology to identify cybersecurity talent at different phases of an individual's career life cycle supports recruitment of high potential talent from diverse backgrounds to increase the numbers of candidates entering cybersecurity education and training programs.

Keywords: Career Guidance, Cybersecurity Workforce Framework, Vulnerability Assessment, Incumbent Worker Training

INTRODUCTION

Early projections in "A Human Capital Crisis in Cybersecurity" [i]are overshadowed by current projections of national[ii] and global demands[iii],[iv] for cybersecurity workers at over 1 million people in the national cybersecurity workforce by 2024. [v] [vi] Societies reliant on the Internet of Things are vulnerable to cyber attacks on critical infrastructures and the internet-based economies. Sufficient quantity of quality cybersecurity talent is a national and global concern.[vii] Discussions in academic and government circles include professionalization of the field leading to career occupations. Perhaps one day professional licensing, based upon education, training and continuing education will be the standard.[viii] The question remains: How do we identify top talent, candidates suited to specific cybersecurity roles?

Multiple factors play into selection of a cybersecurity talent search process. Is it a question of candidates with innate talent or can individuals be nurtured into the field? Secondary factors of this approach require candidates have an intense personal interest, open to coaching and mentoring, and nurtured by a well-structured pedagogical process. [ix] Strategies to fill cybersecurity talent pipelines acknowledge competitions "attract those already committed to the profession than interesting and developing those still exploring their interest."[x] Pipelines to cybersecurity professions traditionally rely on computer science, IT, engineering departments to educate students, and do not have capacity to address the short

and long term demands for cybersecurity professionals. US initiatives, NICE/NIST and DHS/NSA partner to increase awareness of cybersecurity and represents a cultural shift to promote entry into an emergent career field. Gaps exist in assessing the qualifications and potential of candidates including and beyond the technical skills generally associated with computer science/engineers. Cybersecurity requires professionals with strong communication and team skills to work across departments and disciplines,[xi] through identification and career guidance for potential cybersecurity talent.

Benchmarking cybersecurity to medicine is a recurring theme within the cybersecurity research community. In 1910 Abraham Flexner funded by Carnegie Melon transformed American medical education[xii], ultimately leading to the standardization of curriculum [xiii]professionalization of occupations within medicine. Initiatives led by National Initiative Cybersecurity Education[xiv], NIST and the Centers of Academic Excellence network [xv]guided by NSA and DHS parallel Flexner work in the early 20th century. Educational institutions and systems, collaborating with NSA/DHS curriculum standards, grapple with identifying a curricular system reflective of licensed occupations which was addressed by the medical profession.[xvi] Stephanie Keith, Director, Cyber Workforce Management, Department of Veteran Affairs, compared the current state of cybersecurity to where the American medical field was in the early twentieth century during her panel presentation at the NSA Executive Leadership Forum in 2019.

The 2010 study "Psychological Profile of Surgeons and Surgical Residents"[xvii] methodology informed our research team study when selecting NICE job roles, Cybersecurity Defense Analyst, Cybersecurity Defense Infrastructure Responder, Cybersecurity Incident Responder and Cybersecurity Vulnerability Assessment Analyst, within the Protect and Defend NICE Workforce Framework. The original methodology used two of the three components, Job Satisfaction Indicators (JSI) and Career Interests Activities (CIA) to build a profile for surgical burn residents. Acknowledging rigors of medical school, internship and residency programs, as well as the highly competitive vetting process to become a candidate for a surgical residency, administering the Career Training Potential (CTP) was deemed unnecessary. Surgeons and residents ranked by leadership and a performance profile, based upon two of the three WOWI scales ensued. All three scales are described in Methods.

Methods

Cybersecurity workers participants were from seven organizations located in the US Pacific Northwest. They spanned government: federal and state agencies, a national laboratory, and a military unit. The non-government entities included retail, telecommunications and transportation corporations. While twenty organizations were contacted and understood their contribution would impact the professionalization and development of quality cybersecurity talent, the seven participating organizations had the management support, organizational culture, and desire to participate. The final data set was aggregated from 119 cybersecurity professionals.

On-site, online administration of the World of Work Inventory (WOWI) occurred on computers in proctored conference rooms. In addition to the anonymized assessment, human resource departments provided job descriptions and additional information on the individual's performance ranking within the organization's team, their years in the job role and years within the organization was obtained through different methods depending upon the size and culture of the organization. In compliance with the UW Institutional Review Board standards, individual assessments were anonymized and data was aggregated initially by site. The Research data was distributed to different computer networks isolating

assessment results from managers' additional information. Aggregated data was analyzed and interpreted by team members.

Instrument Structure: World of Work Inventory Structure

Three scales comprise the World of Work Inventory (WOWI) providing a comprehensive career profile measuring 35 categories. The WOWI is a multi-dimensional, on-line career assessment. It measures six aptitude and achievement dimensions in the Career Training Potentials, twelve work-style preferences in the Job Satisfaction Indicators and task-relevant preferences related to seventeen career families in the Career Interest Activities. A description of what each dimension's subscales measure is provided below in Tables 3, 4 and 5. [xviii]

Table 3	Measurement of Career Training Potential (CTP)
Verbal	Ability to read and comprehend words. Predictor along with the numerical score of ability to do school work.
Numerical	Ability to manipulate the language of numbers, indicates understanding and skill in performing basic mathematical functions
Abstraction	Potential in the area of figuring out problems through a logical procedure. Ability to solve problems by means of size, position, shape or quantity without assistance from words or numbers.
Spatial-Form	Ability to visualize and think in three dimensions. Ability to formulate a finished product from seeing the visual plans. Potential to sense forms and position of things in space.
Mechanical/ Electrical	Potential to construct, operate and repair machinery and understand physical forces. Also includes the influence of prior knowledge and understanding of electricity, electronics and electromagnetics.
Organizing	Ability to organize information, including the ability to perform sequential reasoning using letters, abbreviations, words and numbers.

Table 4		Characteristics of Job Satisfaction Indicators (JSI) subsets
Versatility	+ -	Likes variety and change; several things going on at once. Likes to concentrate on 1 task at a time; a linear approach to work.
Adaptable to Repetitive Work	+ -	Enjoys predictability; activities in a set order. Likes spontaneity; uncomfortable with tasks that repeat in a short time frame.
Adaptable to Performing Under Specific Instructions	+ -	Adjusts to being monitored; likes to follow set policies, procedures, recipes, instructions, blueprints, etc. Likes general direction/instruction; uncomfortable with close supervision
Dominant	+ -	Likes to lead; be responsible for decisions; is self-directed. Prefers to be in a support role; dislikes being responsible for others.
Gregarious Isolative	+/+ +/- -/+ -/-	Likes to work with others, but also likes to be alone to focus on work and get it done. Likes people and does not like being alone; likes being a team player. Dislikes spontaneous interruption and likes being in control of when others see them. Not motivated by a traditional work environment.
Influencing	+ -	Likes to sell products, services or ideas; enjoys persuading, impressing, and motivating others. Likes to be in situations where there is no conflict; is uncomfortable having to persuade, motivate, or sell to others.
Self-controlled	+ -	Likes to work under pressure, deadlines, and in crisis situations; tends to procrastinate. Prefers calm atmosphere; dislikes constantly working under pressure, against tight deadlines, and meeting demanding quotas.
Values	+ -	Likes to make value judgments; has an intuitive approach to making decisions and solving problems. Dislikes making decisions using intuition or hunches.
Objective	+ -	Likes to problem-solve in a rational way; relies on facts and data. Does not like to rely on facts to make decisions.
Subjective	+ -	Enjoys being self expressive; likes to be creative; is uncomfortable conforming to others' standards of style. Does not have a strong drive to be self-expressive or creative.
Rigorous	+ -	Has integrity of workmanship; tendency toward perfectionism; likes to be detail-oriented. No need for exacting results, likes the big picture, the bottom line; dislikes focusing on details

Table 5 CIA Subscale	Characteristics of Career Interest Activities Subscale
Public Service	Helping others by providing specialized information and services. Includes occupations in medicine, law, education, religion, library work, counseling, the social sciences, etc.
The Sciences	Applying research methods and statistics to solve theoretical and applied problems in the physical, life and social sciences.
Engineering and Related	Using the principles of engineering and physics for the design of machines, materials, instruments, structures, processes and services.
Business Relations	Collecting, analyzing, advising, and making decision based on a variety of data sources. Includes occupations in accounting, insurance, finance, purchasing personnel, human resources, etc.
Managerial	Controlling, directing, and organizing the work of others in a wide range of settings. Requires knowledge of business principles, business operations, and human behavior.
The Arts	Integrating personal expression and art concepts, techniques, and processes to develop works which elicit an emotional or esthetic response. Includes acting, sculpting, painting, etc.
Clerical	Compiling, recording, communicating, computing, copying, and otherwise organizing information for others.
Sales	Interacting with and influencing others in favor of certain products, services, or ideas.
Service	Helping individuals with their personal wants and needs. Includes occupations in cosmetology, day care, recreation, hospitality, food-and-beverage preparation and service, etc.
Processing Machine Work Bench Work Structural Work Mechanical Work Graphic Arts Mining	Working with tools, equipment, materials, products, structures, structural parts, or operating machinery. Includes mechanical, electrical, masonry, and tool and die work, carpentry, plumbing, mining, drafting, factory work, etc.

Data

For candidates coming into this cybersecurity career pathway, having high scores in Verbal, Numerical, Abstraction, Mechanical/ Electrical and Organizing would match the work skills of employees of all seven organizations. Although having innate abilities in these areas would provide an advantage, training in these areas is easily accomplished and would also have a positive impact.

Analysis Summary

Tables

Table 1. WOWI Results of the Seven Participating Organization

Organization 1 n=55		Organization 2 n=17		Organization 3 n=15		Organization 4 n=13		Organization 5 n=12		Organization 6 n=4		Organization 7 n=3	
Verbal	47.05	Verbal	47.76	Verbal	47.07	Verbal	43.69	Verbal	46.17	MeElW	47.25	Verbal	45.33
Numeri	41.67	Numeri	41.88	Abstract	40.00	Numeri	43.08	Numeri	40.67	Numeri	44.00	MeElW	44.33
Abstract	40.44	Abstract	41.65	Numeri	36.53	Abstrac t	42.46	MeEl	36.67	Abstract	44.00	Numeri	42.67
MeEl	37.89	MeEl	37.65	MeEl	35.73	Manag e	40.38	Abstrac	36.33	Engine	43.75	SelfCnt	42.00
Spatial	33.31	Organi	32.47	Object	32.67	MeEl	37.54	Spatial	34.00	Rigor	42.00	Abstrac	40.00
Organi	32.80	Spatial	31.29	Organi	32.00	Organi	36.0	Organi	31.33	Verbal	41.50	MeEl	40.00

Table 1 lists the number of participants of each organization with the mean for the 6 highest scoring areas of the seven organizations. Each organization's data is sorted by the mean from high to low.

Table 2. Number of High Scoring Areas Common among the Different Organizations

Variable Label	WOWI Scale	#
Verbal	Verbal	7
Numeric	Numerical	7
Abstract	Abstraction	7
MeEl	Mechanical/Electrical (aptitude)	6
Organi	Organizing	5
Spatial	Spatial	3
MeElW	Mechanical/Electrical Work (interest area)	2
Engine	Engineering & Related	1
Manage	Managerial	1
Object	Objective	1
Rigor	Rigorous	1
SelfCnt	Self-Controlled	1

Table 2 shows Verbal, Numerical, Abstraction, Mechanical/Electrical and Organizing are among the highest scoring areas for the seven organizations.

Data issues

Based upon the methodology, this format has the potential for bias in the results. Organizations scheduled time for their workers to participate. Ultimately individuals self-selected into the study as participation was not mandatory. Leadership ranking results indicated organizations' team members were above average to high performers. No data was collected from individuals identified as being poor performers.

The sample size for each organization was generally small and was particularly small for organization 6 and 7. Recommendations for future research from a data perspective would include larger sample sizes. Research format could be adapted to administer the WOWI to populations, such as students or incumbent workers, prior to cybersecurity education or training. Upon completion of the training high performance profiles could be correlated with the WOWI profiles.

Interpretation of the data

Generally, performance dimensions (e.g., Knowledge, Skills & Abilities), process characteristics (e.g., work styles) and content preferences (e.g., task-relevant interests) are among the strongest predictors of good person-job fit. They are therefore useful for a priori identification of likely high achieving individuals in the selection process.

This study clearly highlighted the relevance of the performance dimensions, as measured by the Career Training Potentials subscales of the WOWI, for identifying high performing cybersecurity professionals. These tend to be first order predictors of good person-job fit and they emerged as such in this research. High scores in the Verbal, Numerical, Abstraction, Mechanical/Electrical and Organizing Skill were important factors for the cybersecurity professionals studied across virtually all seven organizations. This indicates that - at least for the Cybersecurity Defense Analyst, Cybersecurity Defense Infrastructure Responder, Cybersecurity Incident Responder and Cybersecurity Vulnerability Assessment Analyst studied – these skills consistently are central to doing their jobs well. As a result, in addition to using the standard industry criteria for selection, this suggests including measures of the above mentioned aptitude and achievement areas, as well.

The process characteristics (a second order predictor, measured by the WOWI's Job Satisfaction Indicator scales) and the content preferences (a third order predictor, measured by the WOWI's Career Interest Activities) did not emerge as consistent predictors of high achieving individuals across organizations. We believe this is because of increased error variance introduced by at least four limitations of the present study. First, there were generally small sample sizes from each organization. Second, data was obtained only from high performing cybersecurity professionals. Third, data was collected on four different cybersecurity jobs. Fourth, each job and the organizational culture within which it was embedded contributed to additional uncontrolled sources of error variance. Consequently, this study was unable to obtain the statistical power to identify important characteristics, beyond the performance dimensions, which we believe would have emerged as consistent and statistically significant characteristics common to all high performing cybersecurity professionals across organizations. Further, based on previous research on other occupations, we contend that by remedying these limitations we would be able to identify at least three to five statistically significant factors in each of the WOWI's three major scales that would reliably distinguish high performing from low performing cybersecurity professionals.

CONCLUSIONS

Results from this study indicated that Verbal, Numerical, and Abstraction areas were among the highest scoring classifications for 100% of the participating organizations and the Mechanical/Electrical Work and Organizing categories were common to over 70% of study participants.

The cybersecurity talent pipelines tend to rely on computer science, IT, engineering departments to educate students. These fields do not have the capacity to meet the current and rapidly increasing demand for cybersecurity talent. The importance of the Verbal classification in this study may possibly indicate these cybersecurity professionals are a small select group of computer science and engineering major with high verbal aptitudes; these cyber people are coming from other high verbal majors such as business or liberal arts; and/or, since participants self-selected, high verbal people disproportionally volunteered for this study. Verbal, Numerical, and Abstraction capabilities are considered general education requirements for most higher educational institutions. Capitalizing on these attributes could expand recruitment to departments outside of computer science, IT and engineering to find individuals with strong soft skills who could be nurtured into a variety of cybersecurity roles.

The demand for critical thinkers adept at delivering cybersecurity to decision makers with diverse technical and non-technical backgrounds is growing[xix] [xx]. According to a Wall Street Journal Survey of 900 executives, "92% said soft skills were equally" important as hard skills. Multidimensional assessment

tools, such as the WOWI, could help predict additional factors such as Job Satisfaction Indicators, soft skills, task-relevant career interests, and openness to mentoring and adapting to workplace environments. Continued research incorporating these additional scales can significantly increase the number of students, incumbent and transitional workers capable of succeeding as cybersecurity professionals.

Recommendations

Based upon the growing demand for workers and the growing diversity in the field, continued psychometric profiling to expand the pool of potential cybersecurity workers is essential. A next step could engage major corporations, employing large numbers of cybersecurity professionals, in research design and execution to resolve the limitations of the present study. An additional benefit this approach provides is access to larger teams performing consistent tasks. Studying large numbers of high-performing and low-performing cybersecurity professionals would also provide sufficient data allowing any consistent differentiating factors within both the JSI and CIA scales to emerge.

Replicate this study using work roles from different NICE Specialties with distinct different sets of knowledge, skills, abilities (KSAs) and Tasks. Building a body of data that will differentiate specific KSAs which will define ideal psychometric profiles of individuals capable of high performance in targeted cybersecurity specialties.

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