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13. ABSTRACT (Maximum 200 words): The research used the C-TEAM computer microworld to investigate non-cognitive factors that are associated with effective team performance in complex technological environments. Sixteen four-person teams were longitudinally tracked over a six-week period whilst they performed an air-traffic control task of varying complexity. Results indicated that personality characteristics, specifically conscientiousness, predict team performance, but that this relationship is moderated by the aggregation method. Contrary to most research and theory, our data indicated that team cohesiveness is an outcome, not a predictor, of team performance. Results also indicated that teams performed better when they developed cohesive, task-specific mental models. The current data is being used to further investigate the competencies and non-cognitive factors that are associated with distributed team performance in digital environments.				
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FINAL TECHNICAL REPORT

GRANT #: N00014-01-1-0917

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GRANT TITLE: Selecting and Classifying the "Good Sailor": Exploring the Non-Cognitive Predictors of Expert Team Performance in Complex Technological Contexts

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OBJECTIVE: The research will identify non-cognitive factors that are associated with competencies that are predictive of expert team performance. We will develop descriptive quantitative models based on these factors. This will have significant implications for the selection and classification of Navy personnel who will inevitably be working in teams on technologically complex tasks.

APPROACH: The research used the Controller Teamwork Evaluation and Assessment Methodology (C-TEAM computer microworld) that was developed by the Human Resources Research Division of the Civil Aeromedical Institute at the FAA. C-TEAM is a multisector research platform designed to simulate radar-based air traffic control tasks. The C-TEAM research platform consists of five (four clients and a remote server) 80486/DX2 personal computers. C-TEAM includes a scenario generator that allows the experimenter to create scenarios and incorporate a large number of experimental manipulations. Several measures of performance are automatically tracked by the software, including separation errors, standard protocol deviations, and percent of aircraft reaching destination. This performance data is automatically written to a replay file. The replay data file is detailed enough to allow playback of the performance in its entirety, including all control actions issued by the sector controllers. The software allows sector controllers to communicate with each other. The controllers can coordinate handoffs, issue restrictions, and deliver other inter-sector communications using computer-mediated communication.

Our approach derives from previous theory and research suggesting that certain team competencies predict effective team performance. Our model extends that of previous work on expert teams by (a) proposing that non-cognitive individual difference variables will predict the development of team competencies, and (b) testing these relationships in a complex technological environment. Several novice and expert teams will perform simulations of varying difficulty levels using C-TEAM, a computer microworld simulation of an air-traffic control environment. We will examine the relationships

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among individual difference variables, and the development of team competencies and team performance over time.

CONCLUSIONS: There are several conclusions that can be drawn from the research to date:

- (1) The use of computer microworld environments (such as C-TEAM) facilitates research on teams by enabling longitudinal study of team performance in complex technological environments.
- (2) Personality, specifically conscientiousness, does predict team performance. However, a "team's personality" must be represented in such a way as to reflect the nature of the task performance. By considering the nature of the task performance, and aggregating predictors accordingly, personality was found to be a strong predictor of team performance.
- (3) Results from the research offer consistent and strong support for the causal inference that team performance predicts team cohesiveness and not vice versa. This contradicts much theory and research that has suggested that performance precedes cohesiveness. We have discovered that teams do not have to be cohesive to start with in order to perform well. Providing teams with tasks that they can succeed in is a more effective way to increase cohesiveness.
- (4) The research also indicates that more effective teams tend to develop more cohesive or similar mental models, specifically in terms of the way in which team members approach the task. We see this as an important area for future research.
- (5) The research has developed a measure of expert team performance based on the Cochran-Weiss-Shanteau (CWS) index of individual expertise. CWS assumes that expert teams can discriminate among similar (but not equivalent) stimuli, and that they are consistent in their judgments of identical stimuli. The team CWS measure was successful in capturing changes in team performance on tasks of varying complexity. It was also correlated with other measures of team performance, and capable of tracking team performance longitudinally.
- (6) Many team tasks involve maintenance activities that can be monotonous in nature. The research also investigated individual's proneness to boredom and its prediction of actual boredom on the task. The relationship between boredom and the number of errors was also measured for both individuals and teams. Data are currently being analyzed.

SIGNIFICANCE: The current research extended previous research by going beyond predicting initial performance to study the forecasting of expert team performance in a complex decision-making and problem-solving environment. Currently the primary instrument for selection and classification of Navy personnel is the ASVAB. The ASVAB test battery consists of ten subtests representing four cognitive abilities: Verbal Ability, Mathematical Ability, Technical Knowledge, and Perceptual Speed. While there is considerable evidence of the predictive validity of such cognitive factors, there is a need to assess whether non-cognitive variables can explain additional variance in task performance. The current research studied the relationships between several non-cognitive factors and team competencies and performance. The goal was to determine the

extent to which these non-cognitive variables could explain individual and team task performance beyond cognitive factors.

There has been a shift in the content and scope of jobs defined by current classification models (*Sailor 21*, p.28). Current selection and classification procedures are sufficient for selecting individuals based on isolated component abilities. In the future, however, sailors will need to be able to effectively perform in teams on dynamic and complex tasks. Consequently, selection and classification tools need to be developed to predict those competencies necessary to perform these team tasks.

As noted above, Navy force structure is in the midst of profound structural changes. Tasks are becoming technologically more complex and are increasingly performed in teams. One implication of these changes is that selection and classification procedures will have to be redefined to identify knowledge, aptitudes and skills that are required to operate in these new task environments. The current study assessed several of those competencies that are associated with individual and team task performance in complex, dynamic technological contexts.

In sum then, the benefits of the proposed research to the Navy are:

- Improve recruitment procedures by identifying those knowledge, skills, and attitudes that are associated with effective team performance.
- Reduce the costs associated with early attrition by selecting recruits with the necessary skills and personality characteristics to match the kinds of technologically complex and team environments that they will be operating in.
- Improve the quality of new recruits by going beyond looking at selection and classification procedures based solely on cognitive factors.
- Improve job satisfaction by ensuring that sailors are selected and classified into jobs with the appropriate skills, attitudes and competencies.
- Improve future fleet readiness by selecting on the basis of skills and attributes more suited to the upcoming technological and team climate.

One of the products of the current research is the development of a microworld protocol that enables research on teams performing in technologically complex environments. This has enormous implications for selection and training in both the military and industrial worlds. As technology becomes more sophisticated and more reliance is placed on teamwork, research methodologies such as that being developed at Kansas State University will become invaluable. Our long-term goal is to use these research insights to develop several tools that can be used to identify individuals with the best potential to perform well in a team environment.

**AWARD INFORMATION:** The grant has funded four graduate students and three undergraduate students. The research has generated one Masters Thesis and one Doctoral Dissertation.

BOOK CHAPTERS, SUBMISSIONS, ABSTRACTS AND OTHER PUBLICATIONS:  
*Publications*

Friel, B. M., Thomas, R. P., Raacke, J., & Shanteau, J. (2001). Utilizing CWS to track the longitudinal development of expertise. *Proceedings of the Annual Meeting of the Human Factors and Ergonomics Society*. Minneapolis/St. Paul, MN.

Thomas, R. P., Willem, B., Shanteau, J., Raacke, J., & Friel, B. M., (2001). Measuring performance of expert controllers: An application to air traffic control *Proceedings of the 45th Annual Meeting of the Human Factors and Ergonomics Society*. Minneapolis/St. Paul, MN.

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### *Papers Presented*

Shanteau, J., Thomas, R. P., & Friel, B. M. *Development of expertise in a complex decision-making environment*. Paper presented at the Conference on Experienced Based Decision Making, Heidelberg, Germany. February 2002.

Egleston, D. O., & Fullagar, C. J. *Big-5 and Team Performance in Complex, Computer-Mediated Environments*. Paper presented at the Midwest Psychology Association, Chicago. May 2002.

Fullagar, C.J., & Egleston, D.O. *Using Microworlds to Understand the Relationship Between Team Cohesiveness and Team Performance*. Paper presented at the 17<sup>th</sup> Annual Conference of the Society for Industrial and Organizational Psychology, Toronto. April 2002.

Fullagar, C.J., Egleston, D.O., & Shanteau, J. *Using Computer Microworlds to Study Teams*. Paper presented at Annual Convention of the American Psychological Society, New Orleans. June 2002.

Fullagar, C.J., & Shanteau, J. *Selecting and Classifying the "Good Sailor": Exploring the Non-Cognitive Predictors of Expert Team Performance in Complex Technological Contexts*. Paper presented at the Fifth International Military Applications Symposium, Memphis. June 2002.

Shanteau, J. *Behavioral Definition of Expertise Without Using External Criteria*. Paper presented at Annual Convention of the American Psychological Society, New Orleans. June 2002.

Raacke, J., Thomas, R. P., & Friel, B. M., Shanteau, J. (2001). *Development of team expertise in a dynamic stimulus environment*. Paper presented at the 2001 Society for Judgment and Decision Making Conference, Orlando, Florida.

Thomas, R. P., Willem, B., Shanteau, J., Raacke, J., & Friel, B. M., (October, 2001). *Measuring the performance of expert controllers*. Paper presented at the Human Factors Conference, Minneapolis, MN.

Friel, B., Thomas, R. P., Raacke, J., & Shanteau, J. (October, 2001). *Longitudinal development of expertise*. Paper presented at the Human Factors Conference, Minneapolis, MN.