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NPRST-TN-09-4

February 2009

Investigating the Incorporation of Personality Constructs into IMPRINT

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Navy Personnel Research, Studies, and Technology

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Millington, TN 38055-1000
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REPORT DOCUMENTATION PAGE				<i>Form Approved OMB No. 0704-0188</i>	
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1. REPORT DATE (DD-MM-YYYY)		2. REPORT TYPE		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (Include area code)

Foreword

This effort was part of a Congressionally mandated program, funded through various Program Elements, whereby the Navy was directed to adapt a software application, IMPRINT, developed for use in the Army, for use in Navy ship acquisitions. The objective of this study was to determine if it was feasible to incorporate non-cognitive attributes such as stress tolerance into IMPRINT for use as human performance moderators.

David L. Alderton, Ph.D.
Director

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Introduction

This report will review progress in the area of human performance modeling within the context of a Human Systems Integration (HSI) approach, with particular focus on how aspects of personality could contribute to human performance modeling. While personality has been demonstrated to be a modest predictor of job performance (Barrick & Mount, 1991; McHenry, Hough, Toquam, Hanson, & Ashworth, 1990) the relationship between personality and discrete task performance in varying environmental conditions has not been rigorously studied. This report will detail how personality constructs originally developed for purposes of selection and classification might be utilized to enhance current models of human performance and how personality constructs could be included in a specific Human Performance Modeling (HPM) tool, the Improved Performance Research Integration Tool (IMPRINT). Other areas where additional work could contribute to a broader, more useful HSI process for the Navy will also be addressed.

Recent trends have resulted in the recognition that construction of accurate models of human behavior will benefit the Navy in myriad ways. As noted by Zachary, Campbell, Laughery, Glenn, and Cannon-Bowers (2001):

“At the same time, both industry and the government (particularly the military) are facing challenges that are driving the need for human performance models. For example, the Department of Defense (DoD) is requiring that future Navy ships must be built with reduced budgets and operated by vastly smaller crews, and must operate effectively and efficiently in mission environments that are complex, difficult to define, and rapidly changing. Thus, the human component is, more than ever, the critical component to mission success.”

The Defense Modeling and Simulation Office (DMSO) “identified the capability to robustly represent individual and group behaviors as a critical need” (Gery, Doyal, Brett, Lebiere, Biefield, & Martin, 2003). While not addressing human behavior models directly, the U.S. Government Accountability Office¹ (GAO, 2003) recommended the Navy “require that ship programs use human systems integration to establish crew size goals and help achieve them” and “formally establish a process to examine and facilitate the adoption of labor saving technologies...across Navy systems.” Implementation of these recommendations will require prediction of performance outcomes of man-machine systems through the use of human behavior models.

Benefits of Adding a Personality Construct Performance Moderator

Adding a personality construct as a performance moderator to the current battery of environmental stressors, training, and personnel moderators would enhance IMPRINT's ability to simulate human behavior and define the complete Warfighter-

¹ Known as the Government Accounting Office prior to July 7, 2004.

system. The most immediate result of implementing a personality construct performance moderator would allow the analysis of personality influences on Warfighter-system performance from mission to function and to task. Additionally, users could identify the types of personality necessary to enhance overall mission effectiveness. This has the potential to directly support the personnel selection process throughout the acquisition cycle. Personnel domain professionals could use the model data to refine recruitment and retention throughout the lifecycle of the system, ensuring consistent mission performance.

Human Systems Integration

Human Systems Integration is a means to reduce overall life cycle costs through consideration of both the system and the human component at an early stage in the acquisition of new systems. As noted in Figure 1 below (GAO, 2003), a significant portion of system life cycle costs are determined early in system development.

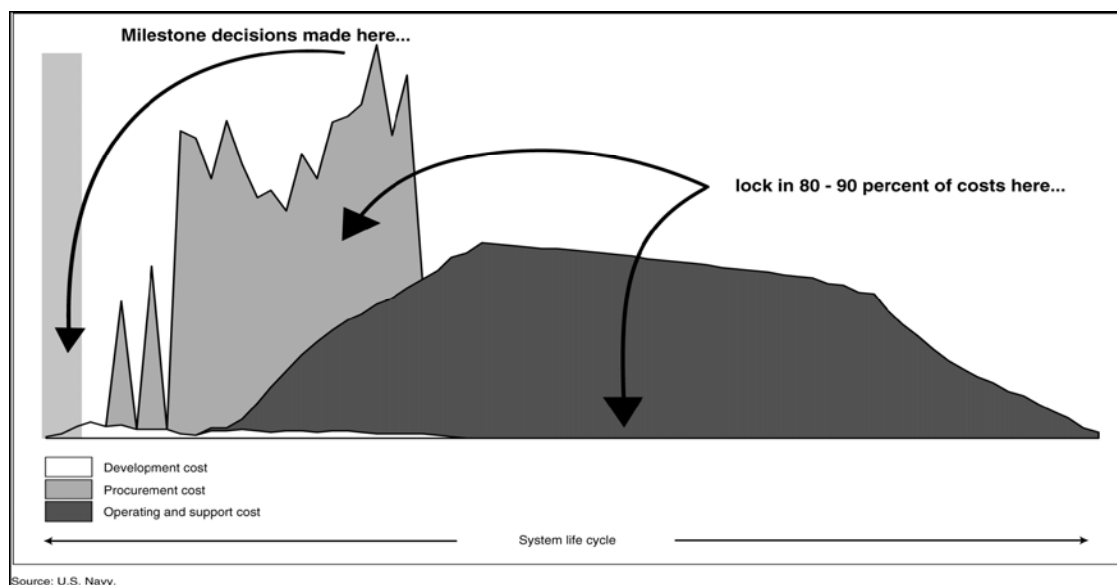


Figure 1. System life cycle costs.

HSI is a methodology for ensuring that systems design and development incorporates the integration of human performance attributes, including cognitive, psychomotor, and perceptual attributes, with system attributes, including hardware and software, to minimize Total Ownership Cost (TOC). The primary focus of HSI is on the development of a system with the human as an integral component, not an afterthought. However, in order to have a robust HSI process it is necessary to construct robust models of human behavior. Models and simulations that include human behavior allow inexpensive exploration of concepts early in system development. These concepts can be analyzed and included in the system design trade-space throughout the development of the system.

Human Behavior Representation

Human behavior representation (HBR) denotes, “...a computer-based model that mimics either the behavior of a single human or the collective action of a team of humans” (Pew & Mavor, 1998). The phrase *human performance modeling* is also used interchangeably with *human behavior representation*, although human performance modeling may also be used more globally (i.e., HBR can be a subset of HPM). More generally, HBR is a group of modeling techniques designed to replicate the actions or behavior of people. Generally these techniques instantiate the relevant behavioral model as software code embedded in a computer simulation that allows for analysis of inputs/outputs and internal processes over time. These models may focus on particular aspects of human behavior such as decision making or they may be linked with other models, such as perceptual processes, that consider more comprehensive, integrated aspects of human behavior. There have been few efforts that have attempted to instantiate aspects of personality into computer models of behavior. Some of these will be discussed in detail in a later section.

Personality constructs that have been developed for selection and classification are customarily not used to predict discrete task performance at the granularity that most instantiated human performance models are able to predict. The interest for selection and classification has been in global measures of job performance. According to Campbell, McHenry, and Wise (1990), whose definition of job performance has proven of great value to the field of personnel psychology, job performance focuses on observable behavior in support of organizational goals. They define job performance as:

“...observable things people do (i.e., behaviors) that are relevant for the goals of the organization. The behaviors that constitute performance can be scaled in terms of the level of performance they represent....There is not one outcome, one factor, or one anything that can be pointed to and labeled as job performance. Job performance really is multidimensional.” (pg. 314)

The particular aspect of HBR that we were interested in for the Navy HSI initiative² was the modeling of a component of job performance, namely task performance. And we were particularly interested in task performance as characterized by two performance outcomes, task-time-to-complete and task accuracy. IMPRINT provides data both on task-time-to-complete and on task accuracy. IMPRINT stressor algorithms currently built into the tool impact performance outcomes based on these measures. Task performance continues to more clearly define the construct of job performance from a behavioral perspective. Task performance and contextual or organizational citizenship behaviors form two focal domains.

² The Navy HSI initiative was originally entitled Systems Engineering Acquisition and Personnel Integration, or SEAPRINT, but was later renamed for clarity.

Task Performance

Task performance can be categorized into two types. The first type “...consists of activities that transform raw materials into the goods and services that are the organization’s products”. The second type “...consists of activities that service and maintain the technical core...” (Motowidlo, Borman, & Schmit, 1997, pg 75). The vast majority of HBR efforts within the HSI context are investigations of differential performance outcomes involving task performance of the first type. The interest is in whether or not job tasks can be clearly expressed and ordered so that predictions can be made about the ability of a proposed man-machine configuration to meet desired operational performance requirements. Task models used in these predictive efforts generally ignore the context within which the tasks are actually performed. Generally, the assumption is that the human component performs the necessary tasks much as an automaton, not requiring breaks or feeling task overload stress and the focus is on task performance.

Performance Moderators

Performance moderators are variables that impact performance behavior. These moderators can be important contributors to human performance models for various reasons. For our consideration, the most important reason is that these moderators can change performance outcomes. Pew and Mavor (1998) distinguish between moderators as being external or internal.

External Moderators

External moderators are external to the individual. They are generally some type of physical stressor and include heat, noise, vibration, and physical workload. Many of these stressors have empirical studies linking stressor levels with clear performance degradation. IMPRINT incorporates various algorithms that allow modelers to account for the impact of physical stressors on task performance, leading to differential mission performance outcomes (Mitchell, 2000).

Internal Moderators

Internal moderators are internal to the individual. Internal moderators include intelligence, level of expertise, emotions, and personality. In IMPRINT differential performance outcomes can be produced by manipulating personnel characteristics as represented by scores from the Armed Services Vocational Aptitude Battery (ASVAB). Attempts to model these internal moderators have only recently appeared.

Personality

The study of personality has long recognized the multidimensionality of human behavior. For example, considerable recent work has centered on the Five Factor Model (FFM) (Barrick, Mount, & Judge, 2001) as an organizing taxonomy for personality. The FFM consists of five dimensions: extraversion, agreeableness, emotional stability, conscientiousness, and openness to experience. Conscientiousness and emotional stability have demonstrated positive correlations with performance across a wide variety of jobs (Barrick & Mount, 1991; McHenry, Hough, Toquam, Hanson, & Ashworth, 1990). However, in general, job performance is operationalized as a global outcome rather than as discrete task performance.

As noted, there is evidence that personality impacts work performance; how will HSI account for it in models and tools? Numerous obstacles to incorporating aspects of personality into models of human behavior exist. Primarily, most models of personality are not instantiated in computer models. There is little research linking the specificity of task performance with explicit personality measures needed to improve human performance models. For example, how does the personality trait of stress tolerance impact performance outcomes of personnel involved in visual recognition tasks? The personnel domain, increasingly engaged with personality constructs, is an excellent place to look for answers.

The Navy Computer Adaptive Personality Scales (NCAPS) (Houston, J. S., & Borman, W. C. (2005), Houston, J. S., Schneider, R. J., Ferstl, K. L., Borman, W. C., Hedge, J. W., Farmer, W. L., & Bearden, R. M. (2003)) is a recently developed personality measurement instrument that is part of the larger Navy Whole Person Assessment (WPA) research effort. It is a prime starting point for the personality construct used in this effort. NCAPS is an innovative instrument developed to assess personal attributes for classifying or screening individuals into U.S. Navy occupations. The ASVAB, a collection of verbal, mathematical, and technical tests, serves as the primary selection and classification instrument for all Navy enlisted jobs and is a substantial predictor of training outcomes. However, many studies have found that considering non-cognitive factors (e.g., personality and interests) enhances the ability to predict successful continuation and performance across both civilian and military jobs. For example, adding measures of conscientiousness and emotional stability to cognitive measures such as the ASVAB can explain an additional 18–38% of the variance in job performance (Ferstl, K. L., Schneider, R. J., Hedge, J. W., Houston, J. S., Borman, W. C., & Farmer, W. L. (2003).

Stress tolerance is the personality construct that was selected from the NCAPS battery to explore for appropriate inclusion with IMPRINT. The construct of stress tolerance was selected because it has been shown to impact task performance and it is currently feasible to model the impact of physical stressors in IMPRINT as they apply to tasks of certain types. The operational end points of stress tolerance are defined as:

- **High Scorers**—Maintain composure and retain ability to think clearly and take effective action when confronted with stressful situations; can readily put aside worries and feelings of guilt; can accept criticism without becoming upset.

- **Low Scorers**—Become indecisive or make poor decisions in times of stress due to loss of composure; prone to feelings of worry, guilt, and vulnerability; are easily upset; tend to ruminate about troubling events and perceived failures; do not take criticism well.

Computer Simulations of Personality

There have been a few recent efforts to include personality in computer simulations of human performance. McKenzie, Petty, and Catanzaro (2003) constructed a simulation that uses a trait-based model of personality to influence the decision outcomes of a military commander. The simulation included anxiety, anger, and independence. Oren and Ghasem-Aghaee (2003) used the FFM as the framework for using fuzzy logic to process personality variables but did not instantiate the proposed system into a computer simulation. Aykroyd, Bachman, Harper, and Hudlicka (2005), building on previous work done with the Methodology for Analysis and Modeling of Individual Differences (MAMID) architecture used an indirect approach to modeling personality traits. They argued that traits impact behavior influencing such cognitive attributes as attention and working memory, leading to defining a cognitive architecture before modeling such individual differences as personality. Zachary, LeMentec, Miller, Read, and Thomas-Meyers (2005) describes the Personality-based Architecture for Cognition (PAC), arguing that personality traits and cultural characteristics are not optional aspects of human behavior but are part of the foundation of human behavior. PAC uses personality traits as part of the foundation for the cognitive process. Using research results from neuroscience and research from personality trait investigation, PAC is conceptualized as a 3-level representation. Later we will explain how some of this work may be expanded upon to roll personality into IMPRINT models via external connections.

Improved Performance Research Integration Tool

Why IMPRINT?

Although there are many human performance analysis software tools currently available, we chose IMPRINT to present the framework for modeling the effect of personality on human performance due to a congressional mandate contained in the National Defense Authorization Acts of 2003 and 2004, specifying the use of IMPRINT in the Navy's HSI program. In 2003, following the lead of the Army's Manpower and Personnel Integration (MANPRINT) program, the Navy initiated the HSI program to define a human-centered design policy for materiel acquisition. HSI formally requires the implementation of the DoD's HSI policy for Navy materiel acquisition, ensuring the systems engineering process includes the Sailor as an integral component during design. We also chose IMPRINT because much of the framework and many of the hooks that will eventually be required to add personality traits into human behavioral representations are already in place within IMPRINT. For example, IMPRINT already

has descriptors of tasks that allow the matching of relevant research to performance degradations in terms of task types. Further, algorithms already exist within IMPRINT for performance moderators broken into Personnel, Training and Stressors (PTS), and the addition of personality constructs would be a logical enhancement to the “P” part of that equation.

History of IMPRINT

In the 1970s the U.S. Air Force, Navy, and Army recognized the need to estimate manpower, personnel, and training (MPT) requirements early in the system acquisition process. The U.S. Navy took the lead by developing the HARDMAN Comparability Methodology (HCM) to analyze the trade space between hardware and manpower. Subsequently, the U.S. Army then adapted HCM, renamed HARDMAN I to include a broader range of weapon systems. A subsequent evolution by the U.S. Army automated the process and was called HARDMAN II. In the mid to late 1980s HARDMAN II evolved, linking MPT to Warfighter-system performance through a set of innovative software analysis modules (Kaplan, 1988). The addition of the software modules warranted a new title, HARDMAN III. In the 1990s, the U.S. Army ported HARDMAN III to the Microsoft Windows platform and renamed the system to the Improved Performance Research Integration Tool (IMPRINT). Since becoming IMPRINT the title has essentially remained the same with only the version number changing as functionality has been improved and features added. Figure 2 shows the history behind the development of IMPRINT.

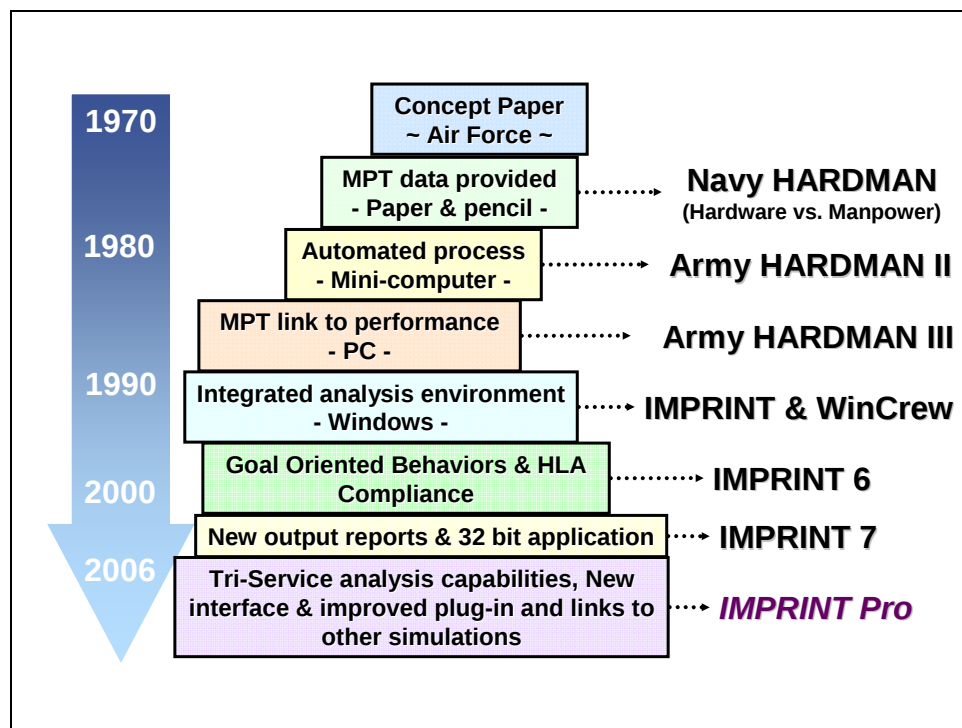


Figure 2. The evolution of IMPRINT.

IMPRINT

IMPRINT is a dynamic, stochastic, discrete event network modeling tool specifically designed for representing and analyzing Warfighter-system performance. To analyze Warfighter-system performance, the user must represent how the total system, whether hardware, software, or system, will be used to accomplish missions through the decomposition of system missions into discrete tasks. Tasks contain precise information about the mission such as mean time to complete, mean accuracy when performing, assigned operator (or hardware/software), and required mental workload (if performed by a human). Given that a Warfighter-system can be adequately represented through a decomposition of the system mission into discrete tasks, a user can employ IMPRINT to answer a multitude of questions concerning the Warfighter-system. The questions listed below present some of the questions an IMPRINT user can answer:

- How much mental workload must an operator expend to perform a task?
- What is the amount of mental workload an operator will expend throughout the mission?
- Are any operators mentally overloaded?
- Did the actual mission time, as predicted by running a simulation, meet the required mission time?
- Can the mission be performed safely with one less operator?

IMPRINT Performance Moderators

In addition to basic task network simulation, IMPRINT is able to predict Warfighter-system performance under diverse conditions through the use of its performance moderators' module that consists of personnel, training, and environmental stressor moderators. With this feature, an analyst can understand the constraints imposed on the system when operating in adverse conditions. For example, the environmental component will moderate the Warfighter performance to account for extreme operating conditions. Currently, IMPRINT has five environmental stressors: heat, cold, noise, hours since waking (a cumulative fatigue stressor), and protective clothing (Mission-Oriented Protective Posture or MOPP gear). Generally, the application of a stressor will in some manner reduce task accuracy and/or increase the time to complete a task.

Similar to the environmental stressors, IMPRINT includes the performance moderators, personnel characteristics and training frequency. The personnel characteristics moderator uses Warfighter aptitude to modify performance. Warfighters with higher aptitude will execute tasks with increased accuracy and in shorter time periods, while Warfighters with lower aptitudes may perform with lower accuracy or require more time to perform the tasks. The training frequency moderator adjusts performance straightforwardly, improving task performance with higher training frequencies and degrading performance when training frequency is lowered.

An important clarification is that an applied stressor, whether environmental, personnel, or training, does not necessarily affect all the tasks of a model. Some tasks remain unaffected regardless of stressor application. Additionally, stressors do not uniformly adjust time or accuracy for the tasks they do affect in a model (Allender, 2000). Consider the example of a typist transcribing a report who occasionally needs to converse in a room with a loud window air conditioner. The typing task will generally be unaffected whereas the conversing task will be severely affected by the noisy air conditioner.

To accommodate these nuances, IMPRINT uses a categorical weighting scheme to describe the required work for performing a task (Fleishman & Quaintance, 1984). While Fleishman identified 53 categories, IMPRINT has winnowed this down to 9 categories, referred to as “taxa” to describe a task (see Figure 3). The nine taxa each belong to one of four general descriptor categories: Perceptual, Cognitive, Motor, and Communication. One caveat of the taxon interface imposed on the user is that a maximum of three taxa may be assigned to a task. This three taxa limit originated due to the technical limitations of a third-party database used in earlier versions of the software. No change has been made to increase the three taxa maximum in subsequent releases of IMPRINT because from a practical perspective no significant difference in performance would be realized as a result of applying a fourth stressor.

Taxon Information

Perceptual:

- ☐ Visual Recognition / Discrimination

Cognitive:

- ☐ Numerical Analysis
- ☐ Information Processing / Problem Solving

Motor:

- ☐ Fine Motor - Discrete
- ☐ Fine Motor - Continuous
- ☐ Gross Motor - Light
- ☐ Gross Motor - Heavy

Communication:

- ☐ Oral
- ☐ Reading and Writing

Figure 3. IMPRINT's nine taxa.

Using the taxon interface to describe the required work of a task allows the stressor algorithms to affect the appropriate tasks in the simulation. In the example of the typist discussed previously, the taxon “Motor: Fine Motor—Discrete” describes the typing task and the taxon “Communication: Oral” describes the conversing task. When the user applies the noise stressor, the conversing task’s performance degrades whereas the typing task remains unchanged. If, on the other hand, the user applies the cold stressor instead of noise, the typing task’s performance degrades and the conversing task’s performance remains unchanged. Table 1 reveals how the five environmental stressors currently affect task performance through taxon assignment.

Table 1
Environmental stressor effects on taxa

Taxon	MOPP	Heat	Cold	Noise	Sleepless Hours
Visual	T	A	T		
Numerical		A			T, A
Cognitive		A			T, A
Fine Motor Discrete	T	A	T		
Fine Motor Continuous					
Gross Motor Light	T		T		
Gross Motor Heavy					
Commo. (Read & Write)		A			
Commo. (Oral)	T	A	A		

Where T = affects task time; A = affects task accuracy.

New Performance Moderator Implementation Methods in IMPRINT

There are four basic options currently available for implementing new performance moderators into IMPRINT. Each of them will be explained below, and a discussion of potential “fits” for adding a personality construct moderator, such as stress tolerance, will be discussed in more detail in the section that follows.

The first option for implementing a new performance moderator into IMPRINT is to add one to the existing PTS interfaces with underlying algorithms that impact task performance, in terms of time and accuracy, based on task types as defined by taxon weights. For this implementation option, data must be available or obtained through rigorous studies on task performance under varied conditions for the performance moderator chosen. This option requires changes to IMPRINT source code, and therefore also supplies other IMPRINT users with the new functionality.

The second implementation option would be to add a “custom stressor” into a specific IMPRINT mission model or collection of mission models called an analysis. This custom stressor would be hooked to task taxon weights similar to the built-in moderators; however, the user will control how tasks are changed based on these weights by supplying their own algorithms which may apply only to a limited study. This

implementation option does not require any change to IMPRINT source code; and is, therefore, also not reusable by other members of the IMPRINT user community without having to recreate it separately.

A third implementation option is to use IMPRINT user code, such as variables and expressions in release conditions, beginning and ending effects, and path logic, to change the way specific mission models are performed based on “moderator variables” or conditions set by variables representing the moderators that a skilled modeler wants to represent. This implementation method also does not require any change to IMPRINT source code, although it is even less transferable to other users because it will likely be very specific to the systems and missions being studied by the modeler.

A final option for implementing performance moderator effects is to build calls into a model, and necessary software code around a model, to allow it to ask external representations of higher fidelity “thinkers” for behavior. In this option, the modeler must also have a representation of the moderators to be used in their own variables (as in the third option); however, if the software around the model (or around IMPRINT, in something called a “plug-in”) is built correctly, there may be some transferability and reusability to this solution.

Personality Construct Performance Moderator Design

As we studied the data and literature currently available on personality constructs such as those included in NCAPS, and then focused more closely on the construct of stress tolerance, it became apparent that currently available data did not support the inclusion of a new personality-based performance moderator into IMPRINT per the first option listed in the previous section. However, through research and various discussions, we were able to develop potential approaches for future performance moderator design, should empirical data to support the moderators become available.

Empirically, it would seem to make sense that tasks that are largely cognitive in nature (in terms of IMPRINT taxa) would be more prone to be impacted by stress tolerance. However, just because a task is largely cognitive, that does not necessarily indicate that the task is mentally taxing. In fact, mental workload as represented by IMPRINT includes the mental capacity required to handle other tasks types as well as “cognitive” tasks, including visual tasks, motor tasks, auditory tasks, and speech tasks. In addition to the ability to represent tasks in terms of the taxa described above, IMPRINT also allows a user to assign levels of mental workload for each task in different mental workload channels. Further, as a model executes, total mental workload over time is calculated, including workload encountered when multiple tasks are being performed concurrently.

We see a potential opportunity to utilize this total mental workload encountered, potentially in combination with other user defined variables related to stress tolerance, to model both perceived levels of stress and the impacts of those levels on operators with different levels of stress tolerance. For example, if an operator has a high current overall workload score, and also is performing a task that has been tagged as “urgent” or “sensitive” or “stressful,” that operator may be more likely to make an error (which could be represented either via a change in task accuracy or some other variable that

creates a “recovery path” in the model) or have degraded task performance. This solution will largely be based on the third generic option listed above. However, if data to support links between stress tolerance, mental workload, and task performance can be found, some of the individual algorithms built into test mission models may be transferable to other modelers and added to IMPRINT.

Finally, another future implementation option or design would be to add personality models, possibly per some of those discussed earlier in this paper, to higher fidelity thinking models such as Recognition Primed Decision-making (RPD) or ACT-R. IMPRINT has already been successfully connected with these higher fidelity thinking models, therefore adding the personality models to them would allow their inclusion in IMPRINT simulations should similar linkage occur.

Future Personality Construct Performance Moderator Development

While personality has been demonstrated to be a good predictor of job performance, the relationship between personality and discrete task performance in varying environmental conditions has not been rigorously studied. Nor has the relationship between personality traits, work outcome, and the interplay of personality traits between team members been rigorously studied. The proposed work outlined here will address the dearth of research and may provide valuable information for HSI developments. This work consists of three phases, outlined below.

Phase 1: Literature Review and Feasibility Study

A comprehensive review of the literature reporting the relationships between personality measures and individual work outcome, and personality measures and team performance will be conducted. An analysis of the research to date summarizing past research, emphasizing discrete task performance for individuals and teams, and a detailed plan for phase 2 will be developed.

Phase 2: Proof-of-Concept Study

The performance measures of three high fidelity simulators measuring individual and team performance and approved by the HSI team will be utilized as the criterion measures to determine the relationship between individual and team task performance and relevant personality traits measured by NCAPS. Criteria will be established for simulator selection which will include but not be limited to (1) high fidelity measurements of performance (reaction time, error rate...), (2) realistic representation of a variety of environmental conditions, and (3) measurement of team performance. The results will quantify the relationship between personality levels and discrete task performance for individuals and teams. The relationships between personality trait levels required by members of the teams will also be provided. It is possible that trait level tradeoffs can exist between team members (i.e., one team member with a particular level of a trait can compensate for another team member with a low level of a particular trait) and team performance can remain optimal.

Phase 3: Live Operations Study

As part of a live operations study, the measured work performance of individuals and/or teams in at least 3 different work environments will be utilized as the criterion measures to determine the relationship between individual and team task performance and the NCAPS traits. Trait levels, work outcome, and tradeoffs will be examined and recommendations for including personality into the HSI process will be provided.

Other Future Directions

In addition to potential future work related to WPA personality constructs such as stress tolerance to enhance personnel performance moderators in IMPRINT, the authors also identified other potential enhancements that could be made in IMPRINT applicable to the Navy's personnel and manpower domains. These ideas are briefly summarized below.

Inventory Management Projections

IMPRINT currently has Army specific personnel data libraries (based on Army Military Occupational Specialty, or MOS, categories) with which it was developed and a primitive projection capability for looking at future personnel inventories. Any Navy IMPRINT-like HPM tool must be linked to a more sophisticated inventory management tool that includes the ability to model various constraints on force levels. For example, the Navy's Skilled Personnel Projection for Enlisted Retention (SKIPPER, also known as Enlisted Strategic Analysis Model [ESAM]) tool allows users to project personnel inventory levels by skill by length of service (LOS) and perform various what-if scenarios modeling the impact of varying selective reenlistment bonuses, "A" School constraints, and other policy impacts. The costs of these scenarios could then be modeled and analyzed as noted previously.

Cost Range of Different Configurations

For a human performance modeling tool to be of maximum utility for HSI within the Navy's acquisition process it needs to be closely coupled to a cost model. Information about system performance is valuable; but costing different configurations adds incredible utility and breadth to the model and to the acquisition process. Adding cost modeling could be done modularly so that the model would take input either directly from the HPM tool or from an inventory management tool that projects over some part of the system's lifecycle.

Research Platform

The Navy should investigate the feasibility of developing an HBR research platform that could be used for advancing the “state of the art” in HBR. This could be done through a consortium of universities and private organizations in cooperation with the Navy’s HSI office. Many of the applications from this work would contribute to the Navy’s training communities through the development of more realistic HBR models, including the development of realistic opponent models used in training simulations.

HBR Tools Do Not Specifically Address Team Issues

Current tools used to model human behavior focus on individual behavior. Tools such as IMPRINT, when used by an experienced analyst, can show performance conflicts/bottlenecks that develop in team situations but the tools have been developed with an individual focus. Research into how team performance concepts can be better integrated into existing and future tools and needs to be performed.

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