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## Validation of Individualized Fatigue Assessment Tools for Naval Aviation

Fatigue can result in cognitive and physiological performance deficits such as reduced capacity to maintain high cognitive load, decreased vigilance, and slowed reaction time, and is a major contributor to Naval Aviation flight mishaps. The Naval Safety Center has identified the need for quickly-administered individualized assessment tools to determine a pilot or aircrew member's fatigue state. In response, researchers at the Naval Aerospace Medical Research Laboratory (NAMRL) recently conducted a study of several potential "readiness to fly" assessment tools.

One instrument that was studied, FlightFit, was a 7 to 8-minute computer-administered battery of tests designed to measure fatigue-sensitive cognitive and psychomotor abilities. Component subtests included performance measures of attention shifting, reaction time, short-term memory, pattern scanning, and divided attention. Another instrument studied, PMI-Fit 2000, used eye-tracking and pupillometry to perform a brief (approximately 30-second) assessment of fatigue-related impairment. This instrument measured several characteristics of pupil dilation in addition to saccadic velocity, or eye movement speed.

To evaluate the sensitivity of these instruments to the effects of fatigue, several criterion and outcome measures were also included. These were: the Psychomotor Vigilance Task (PVT), the "gold standard" for detection of fatigue effects on vigilance performance; Synthetic Work for Windows (SynWin), a test of working memory and cognitive load; simulated flight performance using X-Plane 9, an ecologically valid performance measure; and the Stanford Sleepiness Scale, a subjective measure of sleepiness. In addition, participants' predicted fatigue levels and task performance were modeled using the Fatigue Avoidance Scheduling Tool (FAST), a software application that predicts task performance changes in response to specific work and sleep profiles.

The study employed a sleep restriction protocol, in which fifteen (15) active duty military



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personnel from the Naval Aviation Preflight Indoctrination (API) program completed all 6 measures at rested baseline, and then every three hours throughout a 25 hour period of continual wakefulness. A period of continual wakefulness began at 0300 on test day, with testing beginning at 0600 and ending at 0400 the next morning.

Significant effects of sleep restriction were observed for components of both the cognitive and the eye-tracking test batteries. The criterion and outcome measures also showed significant performance decrements over the period of sleep restriction. Specifically PVT, SynWin, X-Plane flight simulator and the SSS, all showed statistically significant performance decrements at the 0000 and 0300 blocks of observation (continual wakefulness of 21-22 and 24-25 hours, respectively). The measures most sensitive to fatigue included the saccadic velocity component of the eye-tracking test, and the attention shifting, short-term memory, and divided attention performance components of the cognitive test battery.

Models of performance impairment generated by the FAST software were statistically significant. FAST predicted performance decrements in vigilance, as measured by the PVT, accounting for 14% of the variance in PVT lapses. However, adding participants' saccadic velocity, divided attention, reaction time, and attention shifting scores to the models increased the accuracy of predictions (variance accounted for in PVT lapses) from 14% to 36%. This is not an extremely surprising result, since a growing body of scientific literature points to the existence of large and stable individual differences in fatigue resistance/susceptibility.

This research was consistent with previous studies in suggesting that fatigue modeling tools such as FAST provide fair predictions of fatigue and performance, and thus may provide utility to schedulers. However, predictions, and more importantly, assessments, of actual fatigue levels among individual aviators could be substantially improved through the addition of individualized fatigue state assessment. Physiological (saccadic velocity) and cognitive characteristics or abilities are sensitive to the effects of sleep-related fatigue, and can be measured relatively quickly and easily.

Although these results are promising, before any of the instruments evaluated in this study could be recommended for operational use, additional research and development is recommended. Several psychometric issues concerning test scoring and norms remain unresolved. Raw scores from both test batteries proved more valid than did the transformed scores reported by the test instruments. The identification of aviation-specific test norms may address this shortcoming. It is also noted that the results of this study apply to acute fatigue resulting from a single day of sleep deprivation. The applicability of these results to conditions of prolonged sleep restriction, as is commonly encountered in military operations is not known. NAMRL anticipates a series of follow-up studies to address these and related questions.

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