Observing the Brain-on-Task using Functional Optical Brain Monitoring

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The efficiency and safety of complex high precision human-machine systems such as in aerospace and robotic surgery are closely related to the cognitive readiness, ability to manage workload and situational awareness of their operators. Subjective operator reports, physiological and behavioral measures are not sufficiently reliable to monitor cognitive overload that can lead to adverse outcomes. A key feature of the concept of mental workload – that reflects how hard the brain is working to meet task demands – is that it can be dissociated from behavioral performance data. Experienced human operators can maintain performance at required levels for a while through increased effort and motivation or strategy changes, even in the face of increased task challenge. Sustained task demands, however, eventually lead to performance decline unless the upward trend in mental workload can be used to predict subsequent performance breakdown. Consequently, it is important to assess mental workload independent of performance measures during training and operational missions. Neuroergonomic approaches based on measures of human brain hemodynamic activity can provide sensitive and reliable assessment of human mental workload in complex training and work environments. Functional near infrared spectroscopy (fNIRS) is a field-deployable non-invasive optical brain monitoring technology that provides a measure of cerebral hemodynamics within the prefrontal cortex in response to sensory, motor, or cognitive activation. This presentation will examine the relationship of the hemodynamic response in the prefrontal cortex to expertise development levels, mental workload state and task performance in a variety of application areas.

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Hasan Ayaz, PhD is an Associate Professor at Drexel University, School of Biomedical Engineering, Science & Health Systems, with adjunct affiliations at the University of Pennsylvania and Children's Hospital of Philadelphia; and a core member of the Cognitive Neuroengineering and Quantitative Experimental Research Collaborative. For more than 17 years, he worked on the development of miniaturized continuous wave near infrared spectroscopy systems focusing on neuroimaging. He has developed tools for monitoring brain function that are now utilized routinely for clinical and field research in university, governmental and corporate labs. He also led the software development of the *first* optical-brain-monitoring based medical device, Infrascanner, which is a portable-handheld instrument that utilizes near infrared to detect hematoma in head trauma patients. Infrascanner, received *de novo* FDA approval, tested with 12 independent clinical studies with 1,200+ patients and currently deployed in 42 countries/6 continents in both civilian and military hospitals, already became the standard of care for children and sports medicine in Europe.

Dr. Ayaz's research involves understanding the neural mechanisms related to human cognitive, and motor functioning with a focus on real-world contexts, mobile neuroimaging, and neuroengineering approaches for neuroergonomics applications. His research aims to design, develop, and utilize (i.e. to measure->elucidate->enable) next generation brain imaging for neuroergonomic applications over a broad-spectrum from aerospace to healthcare. His research has been funded by federal agencies, corporate partners and foundations, and output 200+ publications in international journals and conferences.