REPPERGER RESEARCH INTERN PROGRAM
RESEARCH PROJECT #: AFRL-RHB-20-02

EXPLORING THE VIGILANCE DECREMENT USING NON-INVASIVE NEUROIMAGING TECHNIQUES

PROJECT SYNOPSIS: Vigilance, or sustained attention, is critical in a variety of high-risk military and defense tasks (e.g., air traffic control, cyber operations, air battle management; Warm, Finomore, Vidulich, & Funke, 2015). These tasks require operators to sustain effortful attention over a long period of time to detect rarely occurring target events amid the “noise” of frequently occurring neutral events (Davies & Parasuraman, 1982). Unfortunately, people often have difficulty with these types of tasks and show a decline in their ability to discriminate targets from neutral events over time. This decline, known as the vigilance decrement (Helton & Warm, 2008), poses a serious threat due to the high-risk nature of many of the domains requiring vigilance, particularly because the operators’ primary role in these tasks is to detect when something goes wrong.

A number of psychophysiological metrics have been studied at length along with the vigilance decrement (e.g., Funke et al., 2017). While many of these approaches are promising, we are particularly interested in non-invasive neuroimaging techniques that may provide insight into the neural mechanisms underlying the decrement. Previous vigilance researchers investigating these mechanisms have frequently relied on transcranial Doppler sonography (TCD; e.g., Funke et al., 2017), which utilizes ultrasound signals to monitor cerebral blood flow velocity (CBFV), and functional near-infrared spectroscopy (fNIRS; e.g., Helton et al., 2010), which uses light to measure cerebral oxygenation levels to index mental activity. Studies employing TCD have revealed that the vigilance decrement is frequently accompanied by a temporal decline in CBFV (e.g., Funke et al., 2017), and fNIRS studies suggest the decrement is associated with an increase in oxygenated hemoglobin and regional oxygen saturation in the prefrontal cortex (e.g., Derosière et al., 2013).

However, there are additional gaps in our understanding of the mechanisms of vigilance that can be addressed using TCD and fNIRS. For example, these two neuroimaging technologies provide complimentary information, i.e., regarding the volume of hemodynamic response (TCD) and spatial distribution of neural activity (fNIRS) during task performance, but they are infrequently applied together because of technological constraints (the headsets for each device are incompatible). In addition, previous fNIRS research has largely utilized montages focused exclusively on the prefrontal cortex. By expanding the montage to the full head, additional information regarding changes in the network of active brain areas could be examined as a function of time-on-task.

The goals for this research project are to address these gaps, first by having participants complete the vigilance task in two sessions, once while being monitored by TCD and once with fNIRS, and second by utilizing a full-head fNIRS montage during recording. We predict that temporal reductions in TCD-assessed CBFV will be accompanied by increases in fNIRS assessed cerebral oxygenated hemoglobin in the prefrontal cortex and by concomitant changes in the functional network of brain activity. We believe the outcomes of this research will provide valuable knowledge regarding the underlying mechanisms and states associated with the vigilance decrement, which in turn will inform effective monitoring and mitigation strategies in applied settings.
**Note:** Interested applicants do not need to have previous experience with TCD or fNIRS (though experienced with either is a plus) – training in both neuroimaging techniques will be provided during the internship.

**ACADEMIC LEVEL:** Masters, PhD

**DISCIPLINE NEEDED:** Human Factors Psychology, Experimental Psychology

**RESEARCH LOCATION:** USAFSAM, Wright-Patterson AFB Dayton, OH

**RESEARCH ADVISER:** Gregory Funke, PhD
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Dr. Funke is an Engineering Research Psychologist in the Air Force Research Laboratory’s Cognitive Enhancement and Biodynamics Branch. His current research foci include attention and vigilance, and human-human and human-machine teaming dynamics.