WARFIGHTER PERFORMANCE

Office of Naval Research, Code 34

ONR Warfighter Performance at MHSRS 2024

Mission

The Warfighter Performance department's mission is to enhance warfighter effectiveness and efficiencies through bioengineered and biorobotic systems, medical and behavioral technologies, improved manpower, personnel, and training and systems design.

Vision

- Enhance individual and team decision-making, as well as combat effectiveness, by supplying the correct information to the right people with the required skills at the proper time in the right jobs
- Realize human-system efficiencies to enhance performance and reduce costs
- Create and deliver technologies inspired by biological systems
- Ensure the health and viability of our warfighters afloat and ashore

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DCN #: 543-2233-24, 8/19/2024

WARFIGHTER PERFORMANCE
Code 34 Divisions

Human & Bioengineered Systems (Code 341)

Goals

- Sustained and improved warfighter performance and enhanced decision making in all environments through research and technology development for training and decision-centered design technologies
- Create options for future (perhaps unanticipated) naval decision-making, based upon fundamental understanding gained from cognitive sciences, neurosciences and social sciences and the application of emerging technologies
- Support integrated interdisciplinary research programs

Current Research Interests

ONR's Human and Bioengineered Systems Division seeks innovative proposals in basic research through applied research. Current research areas of interest include, but are not limited to:

- Cognitive sciences
- Computational neurosciences and bio-robotics
- Human factors, organizational design and applied decision-making research
- Social, cultural and behavioral modeling and mission-relevant case studies
- Cyber-social science and social cybersecurity
- Training, Education and Human Performance

Warfighter Protection and Applications (Code 342)

Goals

- Increase the survival of casualties through immediate, life-saving treatment and stabilization
- Improve understanding of what causes injury and how to prevent it
- Prevent stress-induced injury and performance degradation in naval occupations and operationally-relevant environments
- Mitigate health and performance risks in undersea operations
- Utilize biology to expand Warfighter capabilities in the domains of biomaterials, biomanufacturing, bioenergy, bioelectronics and biosensors
- Develop the technology needed to increase the ability of expeditionary forces to utilize unmanned systems

Areas of Interest

The Warfighter Protection and Applications Division seeks technology solutions from a wide range of scientific and engineering disciplines including, but not limited to, biology, biomedical engineering, biotechnology, physiology, pharmacology, and computer and behavioral sciences. Science and technology programs and program pages are listed below.

- Basic Physiological Sciences
- Biotechnology for Naval Applications
- Expeditionary Robotics, Autonomic and Autonomy
- Marine Mammal Health
- Naval Force Health Protection
- Undersea Medicine and Performance

Research Protections (Code 343)

The mission of the Research Protections Division is to ensure that human subject research supported by DON complies with federal regulations, DoD directives, and SECNAVINST 3900.39E CH-1. This includes all research involving human subjects conduced at DON systems and training commands, in operations forces, and at extramural institutions sponsored by the Navy.

DCN #: 543-2233-24, 8/19/2024

WARFIGHTER PERFORMANCE
Code 34 at MHSRS 2024

Tuesday August 27, 8am-10am
Human Performance Optimization in Polar Environments
Location: Coastal 4

Session Presenter: Patrick Mason, Ph.D (Warfighter Performance Department Head)
Session Co-Moderators: Chris Santee, MBA, PPM (Warfighter Performance S&T Department)
Doug Jones (Naval Health Research Center)

Urinary Metabolites Measured at Sea Level Predict Altitude-induced Acute Mountain Sickness Outcome
Presenter Dr. Camilla Mauzy, Air Force Research Lab (Abstract MHSRS-24-12306)

There is current interest in developing simple and unobtrusive methods that can predict Acute Mountain Sickness (AMS) susceptibility. To examine metabolic changes related to AMS susceptibility, metabolomic analyses were conducted on urine samples collected from subjects at sea level and high altitude. In a second human altitude study, 41 unacclimatized, physically active subjects were flown to Taos, New Mexico and spent 4 consecutive days at high altitude (HA). Prevalence and severity of AMS were assessed using the shortened version of the Environmental Symptoms Questionnaire (ESQ) to dichotomize participants into AMS resistant (NoAMS), mild AMS (mAMS) and severe AMS (sAMS).

Beyond the Scope of Altitude Predictive Risk From Terrestrial to Extraterrestrial Life
Presenter Dr. Dylan Dahlquist, Booz Allen Hamilton (Abstract MHSRS-24-13142)

There are clear challenges in accurately predicting Acute Mountain Sickness (AMS) among individuals exposed to high-altitude conditions. The authors current research is centered on compiling existing AMS prediction methods and building a more robust risk calculator that could apply across multiple Department of Defense (DoD) use cases. Not only are military operations at high altitudes of immediate concern, but the emerging field of space travel introduces new dimensions to the study of human adaptability in extreme environments. By consolidating the diverse array of AMS prediction methodologies into a unified, valid, and reliable risk calculator, this solution could be modified to meet current or future research requirements across the DoD.

Feeding the Gut-Muscle-Brain Axis to Support Warfighter Performance During Cold Weather Operations
Presenter Dr. Lynn Kam, Naval Health Research Center (Abstract MHSRS-24-11594)

Wafighters are under high energetic demands and stress during cold weather operations (CWO) due to heavy clothing/equipment, thermoregulation, and unpredictable terrain. Food choices can influence musculoskeletal and cognitive function and incidences of injuries and illnesses. Three Meal Cold Weather meals provides at least 4500 calories a day, which can be enhanced with the Modular Operational Ration Enhancement - Cold Weather/High Altitude pack to provide additional calories and nutrients to support warfighter performance. Despite increased energy needs, warfighters often skip meals and/or snacks due to time, situation, decreased appetite, and personal preference. The purpose of this session is to describe key foods and food components that have been identified to support the gut-muscle-brain axis and potentially improve warfighter performance during CWO.

Non-invasive, Handheld Devices Integrated with Five Sensors for Rapid Assessment of Cold-related Injury
Presenter Dr. Daniel Sim, Air Force Research Lab (Abstract MHSRS-24-10912)

Frostbite or other cold-related skin injury significantly affects Warfighter performance in cold environments. Medical assessment protocols and instrumentation for managing skin injuries are essential to minimize the loss of military personnel. Rapid ways to monitor skin injury objectively during en route care and/or prolonged care are significant before medical providers transport patients with a point of injury to facility-based hospitals. The conventional method to assess skin injury in the field is based on the observers eye or hand. However, these vision and tactile observations are subjective and inaccurate. The objective assessment of skin injury is to non-invasively measure skin properties related to skin health using skin analysis devices. Simultaneous measurements of multiple skin properties offer more comprehensive and reliable skin health assessments. Commercially available skin analyzers typically measure one skin property per device, thus requiring more time and devices to measure multiple properties and not suitable for urgent field applications. Here, we present a handheld device that combines multiple low-cost sensors into a single device that displays skin read-outs from multiple sensors.

Evolution of the Performance of Chemical Exposure Management in Simulated Arctic Conditions
Presenter Dr. Elan Small, University of Colorado Department of Emergency Medicine (Abstract MHSRS-24-12322)

As the Department of Defense increases capabilities in the circumpolar north, Arctic military operations must address exposures to harsh environments including extreme cold. Military medical personnel must be equipped to perform life-saving interventions (LSI) in this setting,

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as well as navigate chemical, biologic, radiologic and nuclear (CBRN) threats including donning protective equipment such as gas masks or Mission Oriented Protective Posture (MOPP) gear. The impact of extreme cold on medical personnel performance, including handling CBRN threats, is not well understood. The goal of this study is to investigate the impact of extreme cold temperatures on cognitive and physical performance of medical personnel performing LSI while navigating CBRN threats and donning appropriate protective gear.

Naval Aircrew Personal Protective Equipment Limitations in Arctic Operations

Presenter Dr. Elan Small, University of Colorado Presenter Dr. Bethany Shivers, Naval Air Warfare Center Aircraft Division

Naval Air Systems Command (NAVAIR) Capability North Stars focus on technological advancements needed to project power further across the globe including to previously inaccessible regions like the Arctic Circle. However, increased operational reach, particularly into the Arctic Circle, increases the probability of downed aircrew in arctic waters and increases the expected search and rescue time. Preliminary review revealed that most aircrew personal protective equipment performance specifications and/or aircrew instructions are not written to include arctic environmental conditions that can reach as low as 28F water and -40 F outside air temperatures resulting in potential performance gaps for aircrew protection and survivability.

Interdisciplinary South Pole Innovation & Research Expedition Study 2022 (INSPIRE22): Hormonal Adaptation and Body Composition in Military Men and Women Crossing Antarctica Unsupported

Presenter Wg Cdr Robert M. Gifford, RAF

Naval Force Health Protection

Dr. Timothy Bentley (timothy.b.bentley6.civ@us.navy.mil), Program Officer, Code 342

The aim of the Naval Force Health Protection program is to research and develop innovative capabilities to protect the warfighter, reduce injury risk and improve combat casualty care while also optimizing performance. The program seeks basic and applied research in neuroscience, bioengineering, biophysics, bio-nano-technology, autonomy and material science to understand the underlying mechanisms of injury and repair, which can be applied broadly to ensure Naval Force Health Protection and Readiness.

Undersea Medicine and Performance

Dr. Sandra Chapman (sandra.e.chapman2.civ@us.navy.mil), Program Officer, Code 342

The aim of Undersea Medicine and Performance is to develop improved methods, models, treatments and devices for understanding, preventing or mitigating factors that negatively impact divers and submariners. Solutions should extend warfighting capability during undersea operations to maximize freedom of action and warfighter dominance.

Marine Mammal Health

Dr. Sandra Chapman (sandra.e.chapman2.civ@us.navy.mil), Program Officer, Code 342

The Marine Mammal Health program aims to improve the detection, treatment and prevention of diseases in U.S. Navy marine mammals to ensure the ongoing health and overall longevity of the animals. The research concentration areas are prevention, detection, and treatment of infectious/non-infectious diseases, medical management of dolphins and sea lions, and clinical and quality of life needs of aging dolphins and sea lions.

Basic Physiological Sciences

LCDR Geirid Morgan (robin.g.morgan2.mil@us.navy.mil), Program Officer, Code 342

This portfolio aims to invest in fundamental and applied human physiology and human factors focused research efforts that are relevant to contemporary and projected U.S. Navy and U.S. Marine Corps operational capability gaps. Current portfolio focus areas include gaining an improved understanding of the physiological/cognitive challenges specific to shipboard damage control activities and maritime mass causalities, as well the development of interventions aimed at improving survivability and recoverability of Sailors in these scenarios. Further this portfolio has equity aimed at improving the understanding of the physiological/cognitive challenges specific to extreme cold region land movements and directed energy exposure, as well the development of interventions aimed at improving survivability and recoverability of warfighters that exposed to these conditions

Manpower, Personnel, Training and Education Information Sciences

LCDR Michael Natali (michael.w.natali.mil@us.navy.mil), Program Officer, Code 341

The Manpower, Personnel, Training, and Education Information Sciences portfolio funds basic and applied research in metrics development, data ontology, data mining and machine learning to optimize performance, personnel screening, training and education opportunities for the warfighter within the Naval enterprise. An underlying premise for all efforts within the portfolio is adherence to sound measurement principles best summarized as reliability (precision), validity (accuracy), and applicability (usability). The program examines various learning and assessment modalities including mobile devices, virtual/augmented realities, and commercially available physiological monitors. The overarching goals are to supply seasoned Naval forces who will "outthink, outfight any adversary" in today and tomorrow's operational environment, as well as reduce unplanned losses & improve retention.

ONR Funded Research at MHSRS
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Tuesday, 27 August | 0915-0930
BREAKOUT SESSION: Military Female Health Research Aimed at Overcoming the Challenges and Barriers Impacting Optimal Warfighter Performance & Operational Readiness
LOCATION: Sun 4

Dynamic Strength Index Differs between Male and Female Entry-level U.S. Marines at the School of Infantry - West

Oral Presentation by Dr. Joshua Winters (Abstract MHSRS-24-11858)

Introduction: Strength and explosive power are critical for military-relevant tasks, and deficits in these qualities are well documented among female servicemembers (SM) .Though these performance components are trainable, complex military environments may not have sufficient resources for performance training; particularly for prescribing individualized programs. Dynamic strength index (DSI), a ratio comparing explosive peak force during a ballistic movement to peak isometric force,4 is often used among strength and conditioning specialists (S&C) to guide training prescription. The purpose of this study was to examine differences in functional strength, explosive power, and DSI between male and female SM currently assigned to the School of Infantry-West (SOI-W).

Methods: This study included 612 healthy active-duty U.S. Marines from the SOI-W (Male: n=470, 20.0±2.5 years, 76.6±9.7kg; Female: n=142; 19.9±2.1 years, 63.4±8.0kg) completing Marine Combat Training or Infantry Marine Course. Participants completed an explosive countermovement jump (CMJ) and an isometric mid-thigh pull (IMTP) using portable force plates. Independent Samples t-tests with Cohen's d effect sizes (d) and Mann-Whitney U tests with correlation coefficients for effect size (r) determined group differences in DSI (CMJ peak concentric force (N)/IMTP peak isometric force (N)), jump height (cm), CMJ peak power (W/kg), CMJ peak concentric force (N/kg), and IMTP peak force (N/kg). Alpha was $p<0.05$ a priori.

Results and Discussion: Females demonstrated lower jump height ($p<0.01$, r=0.57), CMJ peak power ($p<0.01$, r=0.51), CMJ peak concentric force ($p<0.01$, r=0.24) and reduced IMTP peak force ($p<0.01$, d=1.3) compared to males. DSI was significantly higher ($p<0.01$, r=0.24) in females (median DSI=0.81) compared to males (median DSI=0.74).

Significance: Performance training recommendations using standard DSI guidelines (<0.6=ballistic training, 0.6-0.8=concurrent training, >0.8=maximal strength training) suggest greater focus on maximal strength for females and concurrent training focused on a combination of strength and power for males. DSI may be useful for S&C within the military, improving the effectiveness of training program design for large groups of SM at varying levels of performance. At the individual level, S&C coaches could use DSI to guide SM as how to best modify current training to address specific deficits effectively and efficiently.

Funded PI: Dr. Matthew Hoch, University of Kentucky
Managing Program Officer: LCDR Geirid Morgan, Basic Physiological Sciences, Code 342

DCN #: 543-2233-24, 8/19/2024

Genomic and Proteomic Immune Responses Associated with Normobaric Hypercapric-Hyperoxia in Navy Divers

Poster Presentation by Lt Dylan Holly (Abstract MHSRS-24-12040)

POSTER #1811

Introduction: Military diving operations involve prolonged exposure to hyperoxic conditions, which increase the risk of central nervous system O2 toxicity (CNS-OT). Hypercapnia frequently presents as well and can decrease the time to onset of CNS-OT. Considering hypercapnia and hyperoxia can occur concomitantly, evaluating the physiologic interaction of these two stressors may provide insight into the pathogenesis of CNS-OT. Of particular interest are immune system related genes and associated proteins. Therefore, the purpose of this research was to test the hypothesis that hypercapnic-hyperoxia will modify the immune system transcription and translation responses distinct from hypercapnic-normoxia.

Materials & Methods: U.S. Navy divers underwent 2 hours of normobaric gas exposure with varying levels of CO2 (0%, 3%) with either background air or 100% O2. We collected blood samples from divers before gas exposure and 15 minutes post gas exposure. Bulk RNA-seq analysis was performed using whole blood to determine the effects of hypercapnia and hyperoxia on the change in differential expression of RNA ($padj<0.05$) across exposures, followed by pathway enrichment analysis. High resolution tandem mass spectrometry was performed using collected plasma following depletion of top-14 most abundant proteins. Identified proteins with Mascot probability-based scoring ($p<0.05$) were differentially analyzed between hypercapnia and hypercapnic-hyperoxia.

Results: Transcriptome analyses revealed that multiple interferon-related genes were differentially expressed between hypercapnic-normoxic and hyperoxic conditions. Hypercapnic-normoxia led to an upregulation in interferon-related genes while hypercapnic-hyperoxia resulted in downregulation. Conversely, the hypercapnic-hyperoxic condition displayed a greater upregulation of immune-associated proteins such as immunoglobulins, chemokines, tumor necrosis factor proteins, vascular adhesion proteins, calcium-binding proteins, and heat shock proteins.

Conclusion: The opposing genomic and proteomic responses from each condition warrant further investigation. It could be that transcription doesn't equal translation or that post exposure blood draws did not warrant enough time for subsequent protein upregulation to be observed in the hypercapnic-normoxic condition. Future research will hopefully elucidate and help lead to recognition of reliable biomarkers associated with decompression sickness and CNS-OT.

Funded PI: Dr. Luke N. Belval, Naval Submarine Medical Research Laboratory
Managing Program Officer: Dr. Sandra Chapman, Undersea Medicine and Performance, Code 342

DCN #: 543-2233-24, 8/19/2024

Tuesday, 27 August | 1000-1200
POSTER SESSION 1: Undersea Operational Research Panel

Development of a Dive Optimized Localing fNIRS (DOLFN) DEvice to Monitor the Neurocognitive Performance in Navy Divers at Depth
Poster Presentation by Dr. Joel Cooper (Abstract MHSRS-24-13240)

POSTER #1816

Introduction: Navy divers often use rebreather systems with 100% oxygen underwater for gas efficiency. However, prolonged exposure to hyperbaric oxygenation can lead to oxygen toxicity, causing seizures and confusion. The Diver Optimized Localizing functional Near-Infrared Spectroscopy (DOLFN) device aims to detect early signs of oxygen toxicity and other physiological insults in Navy divers during operations.

Capability Description: DOLFN integrates 10 receivers and 8 near-infrared transmitters, offering versatile cortical region coverage. It features multiwavelength LEDs, real-time data streaming via Bluetooth, local data logging for offline measurements, and a head-mounted IMU for motion tracking. Designed for underwater conditions, DOLFN ensures reliable operation during dive missions.

Methods: Built on a COTS Brite system by Artinis Medical Systems, DOLFN comprises a main control unit in a 3-inch acrylic enclosure connected to the fINbox breakout unit via a sealed bulkhead. Dive-hardened components, including watertight cables and epoxy-sealed optodes, ensure functionality up to 300 FSW.

Results: Safety clearance for hyperbaric chamber testing has been obtained and optode functionality validated under pressure. Initial human subject data collection in a hyperbaric chamber has been completed, with dive testing imminent.

Applicability to Medical Roles of Care: DOLFN's ability to detect early signs of declining cerebral blood flow enhances Navy diver safety by providing timely warnings of cognitive decline, potentially preventing accidents. By monitoring cerebral blood flow, DOLFN contributes to proactive risk management.

Impact to the Warfighter: Existing monitoring devices lack sensitivity to changes in cerebral blood flow associated with cognitive performance. DOLFN's ability to measure tissue hemoglobin concentration provides a direct indicator of brain activity, addressing this critical gap in diver safety technology.

Developmental Status of the Technology: Fully functional DOLFN prototype is undergoing rigorous validation testing in both hyperbaric and real-world diving scenarios. Processes for mitigating confounders to signal integrity are being developed to ensure accurate readings. Research to identify relevant brain regions affected by diver health is planned, enhancing DOLFN's diagnostic capabilities. Additionally, based on real-time monitoring, work on algorithms to predict cognitive effects with sufficient lead-time has also begun.

Funded PI: Mr. James Saunders, Triton Systems Inc.
Managing Program Officer: Dr. Sandra Chapman, Undersea Medicine and Performance, Code 342

DCN #: 543-2233-24, 8/19/2024

Spatio-Temporal Localization of High Frequency Pulses for Diagnostics of Directed Energy Effects
Poster Presentation by Dr. Daniel van der Weide (Abstract MHSRS-24-11038)

POSTER
#1709

Directed energy (DE) effects on the human brain are challenging to detect due to various exposure parameters. Understanding these effects is crucial for both diagnostics and developing countermeasures. Techniques like using paraboloidal reflector antennas and exploiting electromagnetic field correlations are essential for localizing high-frequency energy. Incorporating communication system principles can further enhance the detection and diagnosis of potential brain injuries by improving the recovery of weak signals.

In exploring DE-induced dielectric changes in brain tissue, a method using a low-power, pulsed microwave beam and dual-polarized antennas analyzes the scattered energy. This technique involves correlating the scattered signal with the stimulus code, allowing precise localization of the target and reducing irrelevant reflections. By adjusting the amplitude of the stimulus and analyzing the correlation peak amplitude, researchers aim to identify nonlinear behaviors indicative of tissue changes.

A proof-of-principle experiment demonstrated enhanced localization capability using a bistatic coded reflection measurement scheme. Key components included ultrawideband antennas, pulse/data generators, and a high-speed oscilloscope, controlled via MATLAB. The experiment showed that longer code sequences result in better localization accuracy and distinguishability over clutter, even in complex geometries like a skull.

The findings suggest that at power levels below common mobile phones, this method could provide a basis for monitoring baseline conditions in personnel and potentially be adapted for wearable diagnostic tools. The ability to measure correlation peaks accurately in a scattering environment confirms the potential of this approach for diagnosing and assessing DE effects on the human brain.

Funded PI: Dr. Danial van der Weide, University of Wisconsin - Madison
Managing Program Officer: Dr. Tim Bentley, Naval Force Health Protection, Code 342

DCN #: 543-2233-24, 8/19/2024

POSTER #308

Designing Novel Physiologic Monitor Displays for Combat Medics to Reduce Visual Workload and Sustain Cognitive Resilience

Poster Presentation by Ms. Mabel Cummins (Abstract MHSRS-24-11458)

Introduction: The dynamic nature of military operations requires that warfighters exhibit a high level of flexible decision-making under changing environmental demands. One key cognitive capacity at the heart of meeting these demands is the explore-exploit tradeoff—a cognitive strategy that balances how individuals seek out and act upon new information versus how they rely on existing knowledge. Individual differences in the explore-exploit tradeoff can impact a warfighter's approach to problem-solving, risk assessment, and decision-making under uncertainty. Understanding and quantifying the variability in this balance among individuals can offer predictive insights into performance in various military-relevant activities. To do this, we have developed a digitized value-based decision making task, supplemented with computational modeling methods to extract an individual's latent exploratory strategy.

Materials and Methods: We recruited participants from three distinct populations: the general public, average age of 29 (Prolific online database), college students, average age of 20 (University of Minnesota Research Experience Program), and Minnesota Army National Guard, average age of 23. Participants completed the restless three armed bandit test (TBT), along with a neurocognitive assessment battery. The TBT task examines how individuals learn and explore in an environment where the stimulus reward values are changing dynamically over time. We have developed sophisticated computational descriptors that characterize different latent strategies people use to guide their behavior, even when their overall task performance is similar. Results: We observed significant group differences in the exploratory strategy: the National Guard participants explored new choices the most, followed by the college students, while the general population explored the least. While obtaining a similar amount of reward as the general populations, the National Guard group showed worst performance in choosing the optimal choice, likely due to over exploration.

Conclusion: Our findings show robust group differences in the strategic approach to explore uncertain environments across the general and military populations. We are continuing to collect data in the Minnesota Army National Guard population for further comparison and analyses. We aim to determine if the task-derived cognitive metrics could provide predictive insight into individuals' military-related activity performance.

Funded PI: Ms. Mabel Cummins, Vanderbilt University
Managing Program Officer: Ms. Natalie Steinhauser, Code 341

Tuesday, 27 August | 1500-1700
POSTER SESSION 2: Warfighter Brain Health: Advances in Optimizing and Sustaining Cognitive Performance

POSTER #407

Fluid Intelligence as a Predictor of Working Memory in Virtual Reality
Poster Presentation by Mr. Leandro Ledesma (Abstract MHSRS-24-11982)

Introduction: Working Memory (WM) is the ability to hold and manipulate information in the mind, which facilitates goal-oriented behavior. Therefore, WM abilities are useful for military members and could even factor in for military job placement. Fluid intelligence and other IQ measures are reported to be highly correlated with WM abilities. However, there is still debate over the extent to which fluid intelligence and WM relate to each other. In addition, relatively few studies have sought to explore this in a virtual reality (VR) environment, which is becoming more prominent in military related research and training. Thus, our study aimed to close this gap by using a 2-back version of an N-back WM task in VR to investigate the relationship between WM and fluid intelligence.

Materials and Methods: Our sample was composed of 163 (73 females; 44.7%) healthy young adults between the ages of 19-35 (M= 21.64; SD= 3.11). Our 2-back task consisted of 160 trials, of which roughly 36 (20%) were target trials that required the subject to hit a shape that matched the shape shown two items back. Performance for this task was calculated using d-prime, which is the z-scores of the proportion of false alarm rates subtracted from the z-scores of the proportion of target hit rate ($d' = z(H) - z(F)$). For fluid intelligence, we used the Scale 2 Form B of the Culture Fair Intelligence Test (CFIT), which is comprised of four timed non-verbal tests. A raw score was calculated from the sum of correct items from the four tests.

Results: A multiple regression with sex and age as covariates showed that CFIT raw scores significantly predicted d-prime, $R2 = .136$, $F(4,158)= 4.000$, $p< .001$, with larger CFIT raw scores associated with better performance in the N-back (i.e., larger d-prime). Additionally, a separate regression with the same covariates investigated the relationship between CFIT raw scores and the reaction time of correct 2-back target trials, which was also significant $R2= .103$, $F(4,158)= 4.513$, $p<.01$. Interestingly, the model showed that higher CFIT raw scores were associated with slower reaction times for correct target trials, indicating a more careful consideration of trials to reduce false alarm rates.

Conclusion: Our results indicate that higher IQ individuals tend to have better accuracy and more controlled reaction times in WM tasks. These findings further shed light on the relationship between WM and IQ and be beneficial to job placement in the military.

Funded PI: Dr. Elena Grigorenko, University of Houston
Managing Program Officer: LCDR Michael Natali, Manpower, Personnel, Training and Education Information Sciences, Code 341

POSTER #500

Differential Strategic Approaches in Exploring Uncertain Environments: Findings in General and Military Populations

Poster Presentation by Dr. Cathy Chen (Abstract MHSRS-24-13056)

Introduction: The dynamic nature of military operations requires that warfighters exhibit a high level of flexible decision-making under changing environmental demands. One key cognitive capacity at the heart of meeting these demands is the explore-exploit tradeoff—a cognitive strategy that balances how individuals seek out and act upon new information versus how they rely on existing knowledge. Individual differences in the explore-exploit tradeoff can impact a warfighter's approach to problem-solving, risk assessment, and decision-making under uncertainty. Understanding and quantifying the variability in this balance among individuals can offer predictive insights into performance in various military-relevant activities. To do this, we have developed a digitized value-based decision making task, supplemented with computational modeling methods to extract an individual's latent exploratory strategy.

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Funded PI: Dr. Sophia Vinogradov, University of Minnesota Medical School
Managing Program Officer: LCDR Michael Natali, Manpower, Personnel, Training, and Education Information Sciences, Code 341

DCN #: 543-2233-24, 8/19/2024

Tuesday, 27 August | 1500-1700
POSTER SESSION 2: Advances in Diagnosis of TBI: Biomarkers and Beyond

POSTER #302

Head Sensor System for Determining the Acceleration Field of Occupants in a Fuselage Drop Test
Poster Presentation by Mr. Yang Wan (Abstract MHSRS-24-13068)

Mild Traumatic Brain Injury (mTBI) is a prevalent injury among military personnel and difficult to diagnose. Mild Traumatic Brain Injuries are caused by violent head motions, commonly from intense blunt impact like military training, special high-speed boat operating, landing of paratroopers, etc. Most mTBI prevention strategies explicitly or implicitly rely on a "brain injury criterion." A brain injury criterion takes some descriptors of the head's motion as input, like the peak translational acceleration and peak angular acceleration, and then yields a prediction for that motion's potential for causing mTBI as the output. We developed a novel wearable head sensor system that utilizes five inertial sensors to obtain the motion descriptors. The sensor houses both a high-g and low-g accelerometer. We call the head sensor system the Accelo-Hat. Associated with the Accelo-Hat, we developed an algorithm to determine the acceleration field of the head using measurements from sensors. To assess the performance of the Accelo-Hat, we used it on several occupants during a fuselage drop test.

Accelo-Hat collected data from five inertial sensors, labeled #1, #2, #3, #4, and #5. To assess the performance of the head sensor system, we extracted measurements from sensors #1, #2, #3, and #4 of Accelo-Hat installed on the seated ATD, and inputted the data to the AO algorithm to predict the acceleration of the position where sensor #5 was attached. The predicted acceleration matched the acceleration measurement from sensor #5. Further we applied the AO algorithm to predict the acceleration of the center of mass (CM) of the ATD using data from sensors #1, #2, #3, and #4. The predicted acceleration matched the measurement from the CM sensor which was internal to the ATD. The comparison shows that the developed head sensor system is capable of predicting the acceleration field of the occupants' head in the fuselage drop test at arbitrary locations. The accurately predicted kinematics may then be used in brain injury criteria, especially finite-element-based brain injury criteria, to provide a better estimate of a motion's potential for causing injury.

Funded PI: Dr. Haneesh Kesari, School of Engineering Brown University
Managing Program Officer: Dr. Tim Bentley, Naval Force Health Protection, Code 342

DCN #: 543-2233-24, 8/19/2024

Tuesday, 27 August | 1500-1700
POSTER SESSION 2: Advances in Diagnosis of TBI: Biomarkers and Beyond

POSTER
#225

Extraction Technique for Retrieving Connected Skull-brain Samples for Ex-Vivo Mechanical Analysis

Poster Presentation by Dr. Corinne Henak (Abstract MHSRS-24-13068)

Introduction: Traumatic brain injury (TBI), resulting from head trauma causing mechanical damage to brain tissue, affects 40-60% of military personal. A critical tool to understand TBI is finite element (FE) modeling. The accuracy of the FE model is dramatically affected by the interactions between adjacent tissues, such as the meninges, a thin layer of interfacial tissue directly connecting the cortex to the skull. However, obtaining intact skull-brain samples to guide current FE models has proved difficult. Thus, this study presents a process to obtain intact samples of the skull-brain interface for ex-vivo mechanical testing.

Materials and Methods: Porcine heads were collected (within 2 hr of sacrifice) from the Swine Research and Teaching Center, Arlington, WI and stored at -20°C before sample collection. The soft tissue surrounding the skull was removed with scalpel and forceps. Part of the mandible, temporal bone, and zygomatic bone were removed with a horizontal cut parallel with the most ventral point of the eye socket. The remaining temporal and parietal bones had the outer periosteum removed with a scalpel, then were gently ground away until the dura was exposed. A square of skull (~30 mm) was separated with two sets of orthogonal parallel cuts. The meninges and cortex were cut along the edges of the square using a scalpel. To remove the sample, forceps grasped the free skull end to gently pull upwards while a scalpel inserted through the occipital bone spinal column entrance pressed upwards. The weight of the cortex often caused skull-dura or pia-cortex separation. Therefore, a simple proof-of-concept separation test was captured via highspeed camera (Phantom V211 at 100 FPS). The sample was gripped with the skull superior to the cortex, allowing the weight of the cortex to naturally separate the interface.

Results: After development of the extraction method, 2 of 3 attempts resulted in samples. Upon extraction, samples were connected, and only began to fail throughout the separation test. An isolated portion of the pia-cortex interface indicated separation was visible over 600 ms, beginning at the most superior portion of the interface and progressing downwards. In general, separation occurred at the skull-dura or the pia-cortex interface. Separation of the meningeal layers was not observed.

Conclusions: This study presents a novel method for extracting intact samples of the skull-brain interface for ex-vivo mechanical testing.

Funded PI: Dr. Corinne Henak, University of Wisconsin - Madison
Managing Program Officer: Dr. Tim Bentley, Naval Force Health Protection, Code 342

DCN #: 543-2233-24, 8/19/2024

Tuesday, 27 August | 1615-1630
BREAKOUT SESSION: Brain Impact of Sub-concussive Blast Exposure in Military Service Members: Implications for Prevention and Health
LOCATION: Coastal 9

Quantifying Blast Safety Limits to Prevent Sub-concussive Traumatic Brain Injury during Heavy Weapons Training

Oral Presentation by Dr. Rika Calsen (MHSRS-24-11974)

Introduction: Subconcussive traumatic brain injury (TBI) is a major concern among warfighters due to repeated blast exposures that occur during heavy weapons training. A recent post-mortem study indicates that the occurrence of chronic traumatic encephalopathy is low for blast-induced TBI (bTBI) compared to impact-induced TBI. While impact-induced TBI is likely caused by large shear deformations in the brain, we hypothesize that cavitation plays a large role in bTBI, leading to primary neuronal injury. The key objective of the study is to quantify the injury risk from repetitive low level blast exposure and to provide guidelines for safe stand-off distances for heavy weapon systems to prevent bTBI in warfighters.

Methods: A high-fidelity framework is implemented to quantify cavitation-induced neuronal (CIN) injury in warfighters due to blast exposure. A range of peak blast overpressure (BOP) magnitudes and impulses associated with heavy weapon systems (shoulder-fired weapons, artillery, mortar, etc.) is studied: 5 – 90 kPa and 3 – 70 kPa-ms. The framework includes: 1) Numerical modeling of the blast wave interaction with a high-fidelity human body model (GHBMC-M50-Pv5.3.4) to estimate intracranial pressure (ICP) field map of the brain tissue, 2) Calculation of the maximum bubble size at the element level using ICP history data as input to a cavitation bubble growth model, and 3) Quantification of CIN injury based on in-vitro micro-cavitation experiments on neuronal tissue cultures.

Results: Our preliminary results indicate that while the likelihood of CIN injury from heavy weapons training is low, there is still the potential for injury, which may compound for repeated blast exposures. For low level BOP of 2 psi (13.8 kPa) and 4 psi (27.5 kPa) with a 1 ms duration, 0.34% and 0.45% of brain volume is predicted to have a 50% likelihood of CIN injury, respectively. The peak overpressure impulses were 3.16 kPa-ms and 6.3 kPa-ms, respectively. At the higher end of peak BOP from heavy weapons (15 psi), the injured brain volume percentage increases to 7%. An extensive parametric study will be conducted to determine the relationship between blast characteristics and the risk of CIN injury.

Conclusion: We analyzed weapon-specific blast exposure on a high-fidelity human body model to quantify CIN injury and the risk of sub-concussive bTBI. This study will guide the development of safety protocols for heavy weapons training to prevent bTBI in warfighters.

Funded PI: Dr. Rika Calsen, Robert Morris University
Managing Program Officer: Dr. Tim Bentley, Naval Force Health Protection, Code 342

DCN #: 543-2233-24, 8/19/2024

Tuesday, 27 August | 1700-1715
BREAKOUT SESSION: Optimizing Human Weapons System: Utilizing Wearable Sensors to Inform Readiness across the Joint Forces
LOCATION: Sun B

Utilizing Wearable technology to Assess Operational Performance in UMS Operators

Oral Presentation by Mr. Brandon Schrom (Abstract MHSRS-24-12228)

Introduction: Navy Unmanned Maritime Systems (UMS) operators who are tasked with scanning the ocean floor for mine-like objects are required to work on small vessels in varying sea states, weather conditions, in proximity to potential hostile contacts, and, at times, for an extended period. These factors provide a high likelihood for fatigue and poor performance. The current study aimed to assess the ability of wearable technology to monitor readiness levels of UMS platoons and track platoon performance in high-tempo operational training.

Materials and Methods: Platoons were enrolled in a training pipeline for a total of 7 weeks. At the end of the training, the platoons completed a 5-day high operational tempo exercise. Nine UMS operators from Platoon 1 and 12 from Platoon 2 were assigned a Generation 3 Oura ring. The rings collected heart rate, heart rate variability, sleep duration and efficiency, skin temperature, breathing rate, and prior day's activity. These variables were used to calculate a readiness score (range 0-100) to assess a participant's readiness to perform on a given day. The participants were asked to wear the ring throughout the entire Final Evaluation Event (FEE). Operational performance data (errors) were collected from the instructors post hoc.
Results: At the start of the FEE, the readiness scores (mean±SD) were 76.78±5.29 and 68.08±16.70 for Platoon 1 and Platoon 2, respectively. Throughout the exercise, each platoon saw a reduction in readiness until Day 3, after which readiness increased slightly until the end of the exercise. At the end of the FEE, the readiness scores for Platoon 1 and Platoon 2 were 79.71±13.17 and 67.45±14.05, respectively. Platoon 1 made 10 errors: seven mission planning and three operational errors while on station. Platoon 2, however, only made two errors (mission planning), which occurred later in the FEE. Though Platoon 1 had a higher mean readiness score (76.57±9.85) throughout the entire exercise than Platoon 2 (74.99±4.16), Platoon 1 had 5 times the number of errors during the exercise. Thus, the Oura readiness score does not seem to have a clear relationship to operational performance.

Conclusion: While wearable technology can provide great insight into health and human performance, much more information is needed to properly assess operational performance. UMS platoons are small teams working together to achieve a certain mission and may compensate in subtle ways to overcome fatigue.

Funded PI: Dr. Tim Dunn, Naval Health Research Center
Managing Program Officer: LCDR Michael Natali, Manpower, Personnel, Training and Education Information Sciences, Code 341

DCN #: 543-2233-24, 8/19/2024

Wednesday, 28 August | 1000-1200
POSTER SESSION 3: Optimizing the Human Weapon System: Utilizing Wearable Sensors to Inform Readiness across the Joint Force

Deep Learning to Estimate Auditory Salience
Poster Presentation by Dr. Jeffrey B. Bolkhovsky (Abstract MHSRS-24-11290)

POSTER #1702

Introduction: Multiple point-of-care ultrasound (POCUS) applications are known to expedite care and improve outcomes in hospital-based medical environments. Similar benefit is less established in austere or remote environments due to issues with training, expertise, adequacy of ultrasound equipment, and lack of oversight. Just-in-time (JIT) education and deep learning augmented image quality indicators (DLQI) are proposed solutions. The JIT image acquisition tool incorporates schematic and text descriptions of probe placement for each view of an eFAST examination that is displayed simultaneously with a real-time scanning interface. The DLQI tool provides real-time feedback utilizing deep learning algorithms. We postulate that JIT and DLQI image acquisition tools will allow combat medics with minimal prior ultrasound experience to acquire high-quality ultrasound images.

Materials and Methods: We conducted a cross-over study of novice sonographers acquiring eFAST examination images with and without JIT education and a DLQI. Views of the eFAST were obtained in sequential order: Morison's pouch, subxiphoid cardiac, anterior right lung, and anterior left lung. Ultrasound studies were performed on healthy human standardized patients. Novice sonographers were randomized to one of two arms: JIT education and DLQI. Within each arm, subjects were randomized to JIT education or the DLQIs activated. For each view, when the subject perceived they had obtained the highest quality view possible, they recorded a video clip. Clips from each view were reviewed by expert sonographers blinded to whether JIT education or DLQI was used. The expert sonographer graded the quality of the clips using an objective scoring system.

Results: 44 medics captured a total of 2,678 ultrasound images during our study. Morison's pouch image quality significantly improved using JIT and DLQI (P-0.002). There was a non-statistically significant trend towards improved image quality for the right lung view (P-0.23). Medics were unable to obtain minimally acceptable quality images for the subxiphoid view.

Conclusions: JIT education and DLQI are feasible adjuncts to novice sonographers obtaining quality images of select eFAST views. Novice sonographers could not obtain minimally acceptable image quality for the subxiphoid view. Future study should explore whether additional training or alternative views will enable novice sonographers to obtain sufficient quality cardiac ultrasound images.

Funded PI: Dr. Matthew Riscinti, Department of Emergency Medicine Denver Health Medical Center
Managing Program Officer: Dr. Michael Qin, Expeditionary Robotics, Autonomic and Autonomy, Code 342

Wednesday, 28 August | 1000-1200
POSTER SESSION 3: Human Performance Optimization in Polar Environments

POSTER #2005

Enhanced Modeling of Military Helmet Liners for Cold Climate Operations

Poster Presentation by Mr. Andrew Furst (Abstract MHSRS-24-12057)

Introduction: This study explores the viscoelastic properties of polymeric foams, which are pivotal in helmet liners for mitigating traumatic brain injuries in military scenarios. Given the critical influences of temperature and loading rate on foam performance, our research aims to elucidate these factors for improved helmet design. Specifically, we focus on (1) comprehensively characterizing foam behavior across varying strain rates and cold temperatures and (2) creating a sophisticated, temperature-sensitive viscoelastic model to enhance digital engineering of helmet impacts in cold environments.

Materials and Methods: We examined an open-cell polyurethane foam considered for next-generation military helmet design under compression across a spectrum of strain rates (0.001/s to 1000/s) and temperatures corresponding to cold-weather conditions (-20 to 20 C). Employing a combination of a standard load frame, drop-tower, and unique dynamic compression experiments leveraging a Kolsky (or split-Hopkinson bar) apparatus, alongside ultra high-speed imaging and digital image correlation (a full-field optical metrology technique), allowed for precise in-situ kinematics measurement. The experimental data informed the development of a comprehensive viscoelastic material model, applicable over the investigated temperature range.

Results: A detailed dataset on the polyurethane foam's behavior under various conditions was compiled, leading to the creation of an advanced material model for its temperature- and rate-dependent characteristics. This model has been integrated into the Abaqus finite-element software, facilitating the simulation-based helmet design process. Impact simulations at varying impact speeds (10, 14, 17 ft/s), locations (crown, front, rear) and temperatures (-20 to 20 C) showcase the helmet's protective capabilities under cold-weather conditions.

Conclusion: By characterizing and modeling the temperature-dependent properties of helmet liner materials, this research advances the digital engineering of military helmets. The resulting predictive model is a significant step toward optimizing combat helmet systems for brain injury prevention under diverse operational climates.

Funded PI: Dr. David Henann, Brown University
Managing Program Officer: Dr. Tim Bentley, Naval Force Health Protection Program, Code 342

Wednesday, 28 August | 1315-1330
BREAKOUT SESSION: Mental and Behavioral Health Manifestations of Anger
LOCATION: Sun A

Poor Mental Health, Work-related Stress, and Aggressive Behaviour in the Workplace: Findings from a Rapid Response Surveillance Effort

Oral Presentation by Ms. Robyn Englert (MHSRS-24-12309)

A growing body of literature has implicated the role of anger and aggressive behaviors in service members' well-being. Despite several stressors that may be unique to shipboard environments, the prevalence of aggressive behavior has been relatively understudied in shipboard settings. In this secondary analysis of data collected for a Rapid Response Surveillance effort with a U.S. Navy vessel in a prolonged maintenance period, we examined whether self-reported aggressive behavior was associated with work-related stress, poor mental health outcomes, and perceived barriers to seeking mental healthcare. Data were collected from 1,021 sailors using voluntary and anonymous surveys. Participants completed several validated screeners for mental health conditions including PTSD, depression, anxiety, and suicidal ideation. Additionally, participants reported perceptions of 28 work-related stressors, satisfaction with several levels of leadership, and barriers to help-seeking. Aggression was measured using 4 items from the U.S. Naval Unit Behavioral Health Needs Assessment Survey and included reports of how often in the past month sailors yelled or shouted at someone, kicked or smashed something, threatened someone with physical violence, and got into a fight or harmed someone.

The most frequently reported aggressive behaviors were yelling/shouting at someone (54%) and kicking/smashing something (23%). Aggressive behaviors were positively correlated with stressors, operational tempo, and mental health conditions, including suicidal ideation and past suicide attempts. They were negatively correlated with positive perceptions of leadership, that one's duty station are meaningful and rewarding, and intention to reenlist. Those who endorsed aggressive behaviors were also generally more likely to report barriers to seeking mental healthcare. However, those who reported (vs did not report) getting into a physical altercation were less likely to endorse the perception that seeking mental healthcare would harm their careers. These findings underscore the need to understand the scope of aggressive behaviors in shipboard and other military settings to identify avenues to mitigate adverse consequences associated with anger and aggression (e.g., risk to the mission, negative command climate, reduced quality of life, suicide risk).

Funded PI: Dr. Jennifer Belding, Naval Health Research Center
Managing Program Officer: LCDR Michael Natali, Manpower, Personnel, Training, and Education Information Sciences, Code 341

Wednesday, 28 August | 1445-1500
BREAKOUT SESSION: Undersea Operational Research Panel
LOCATION: Coastal 4

Associations Between Submarine Officer Personality and Operational Outcomes

Oral Presentation by Dr. David Clark (Abstract MHSRS-24-11853)

Introduction: There is growing interest in the U.S. Submarine Force and wider military for identifying and developing psychosocial traits in leaders that can improve operational effectiveness. A better understanding of which traits are related to critical performance outcomes is necessary for informing leader development initiatives. The goal of this study was to contribute to this understanding by examining how the personality traits of submarine commanding officers (COs) and executive officers (XOs) are related to an objective metric of operational performance.

Materials and Methods: The sample included n = 139 COs and n = 239 XOs across n = 91 submarines. CO and XO personality was operationalized using the 30 facet scales of the NEO PI-3 (i.e., the Neuroticism, Extraversion, Openness Personality Inventory), a personality assessment based on the "Five Factor" model of personality. Submarine performance was operationalized using People Centeredness Rankings (PCR), a composite score that reflects unplanned losses, qualification pass rate, and re-enlistment rate. There were n = 1881 PCR assessments, each associated with a specific CO—XO—submarine combination. The analysis included a series of Bayesian hierarchical models and Random Forest models with forced cluster effects.

Results: Several associations were identified between officer personality and PCR, with CO traits being more consistently associated with PCR than XO traits. CO traits related to kindness/understanding (e.g., altruism, tendermindedness, and warmth) and instability/erratic behavior (e.g., vulnerability, impulsivity, anxiety) were the most relevant to the PCR. Individual (standardized) regression coefficients in the hierarchical models ranged from approximately +/- .10 to .30, but cumulatively explained a non-trivial proportion of the variance in PCR (e.g., Marginal Bayesian R2 between .06 and .10 for small collections of traits).

Conclusions: Results highlight how the dispositional traits of leaders can relate to operational readiness, and provide evidence in support of incorporating results from personality assessments and behavioral science in the evaluation of leadership effectiveness. Additionally, these results highlight the importance of soft skills in driving operational readiness. Future research will determine which aspects of leader personality are most strongly associated with leadership effectiveness longitudinally across one's career.

Funded PI: Dr. Dominica Hernandez, Naval Submarine Medical Research Laboratory
Managing Program Officer: LCDR Michael Natali, Manpower, Personnel, Training and Education Information Sciences, Code 341

DCN #: 543-2233-24, 8/19/2024

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