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A Generalized Combat Lifecycle Framework for Marksmanship Training and Assessment of Warfighter Readiness

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ABSTRACT

Revelations in neuroscience and human performance optimization acknowledge the strong interplay of cognitive, physical and emotional functions as part of overall performance in both sports and in combat. Within the dynamic environment that is combat, the modern warfighter is required to apply fundamental and technical skills that span multiple levels of physical exertion and cognition concurrently. Furthermore, the modern warfighter must also effectively self-regulate emotional responses inherent to threat of physical harm while effectively task transitioning across these levels. As such, training for and assessments of combat readiness cannot consider individual attributes in isolation, but must pursue a comprehensive approach that is relevant to the requirements of the combat environment. The framework consists of multiple phases representing the progression of a combat event, from patrol/infiltration to initial contact to prosecution to reconsolidation. The phases are comprised of logical memory tests, aerobic tests, sustained power tests, and simulated assessments measuring both tactical acumen, threat identification, threat prioritization, predictive modeling, and other cognitive attributes critical to performance in combat. These tests are chronologically arrayed in a manner representative of the task transitions required by the majority of combat events. Utilizing this realistic framework for training and the resultant data collection enables leaders to acquire a comprehensive model of combat readiness using pillars of performance in an integrated fashion. This framework additionally provides a laboratory for leaders to test the impact of new training curriculum, approaches, and equipment in a contextually relevant manner. Beyond training, given the concern with traumatic brain injury, PTSD, and heavy-metal exposure in a combat environment, this framework provides an opportunity to baseline and measure the impact on integrated physical and cognitive performance over a warfighter's career.

Keywords: Marksmanship simulation, Combat readiness, Training and assessment, Biofeedback, Simulation, Test and evaluation

INTRODUCTION

Innovations in simulation technology and biofeedback sensors, combined with a deeper understanding of neuroscience and human performance allows for a more comprehensive training and assessment of warfighter readiness. Physical capacity, cognitive function, tactical acumen, and stress tolerance can now be trained safely providing after action reviews from multi-dimensional measures with high accuracy. For the greatest training effectiveness, we use a Generalized Combat Lifecycle Framework to train and assess relevant capacities in a manner germane to the experience of combat, simultaneously capturing the relational aspects of these capacities through rapid task transition. The framework mimics the sequential arc of combat, and employs realistic, mixed reality (real weapons firing virtually with recoil and learners moving freely in the large simulated space of real props and virtual scenarios projected on large screens) and biofeedback monitoring (e.g. eye tracking, body tracking, heart rate monitoring) to assess the interplay of physical and cognitive performance relevant to the combat environment.

The modern battlefield is a complex environment that often taxes the modern-day warrior across a wide spectrum of physical, cognitive, and emotional demands. Within the dynamic environment of combat, warfighter draws physical strength, stamina and cognitive acuity simultaneously to coherently apply technical skills, all while regulating the psychological impacts of imminent danger. This interplay of physical, cognitive, and psychological aspects of combat have been widely acknowledged by experienced warfighters. Cognitive neuroscience and human performance field increasingly recognize the strong correlation between physical and cognitive acuity, and its reflection in performance. However, current warfighter assessment methods do not account for the complex interplay between cognitive function, physical exertion, and psychological stress, nor do they test the faculties required for problem solving and rapid task transition. Training events and assessments are rote, and do not possess the contextual relevancy or variability necessary to accurately measure the full-spectrum of human systems in combat, Whereas aerobic and anaerobic performance are often measured separately from decision-making and stress tolerance, modern combat requires warfighters to execute high-stakes decisions while experiencing extreme physical fatigue and cognitive overload due to increasingly complex stimulus. No existing assessment framework systematically integrates these factors in a manner that is observable, quantifiable, and directly relevant to real-world combat. Preventative factors are likely attributed to administrative safety constraints and the lack of a reliable technical approach to assessment.

Innovations in simulation and biofeedback technology now provide the analytical tools required to conducting comprehensive assessments of performance. Cutting-edge marksmanship simulation systems complete with realistic weapon form-factors can provide the variable stimulus necessary to test cognitive acuity in a tactically relevant manner. Integrated biofeedback technology with higher sampling frequencies and reduce sensitivity to interference can simultaneously monitor a warfighter's physiological response to physical and cognitive stimulus. Because simulation systems mitigate the necessity for administrative safety constraints, assessments can more readily approach the stress and complexity of combat in a holistic way. In pursuit of this, we propose employing a Generalized Combat Lifecycle Framework as the structure in which to apply simulation and biofeedback technologies to assess combat readiness. The Generalized Combat Lifecycle Framework structures assessments around combat's natural progression, from patrol to initial contact, prosecution, and reorganization/reconstitution. It measures warfighter readiness by systematically integrating cognitive, physical, and emotional stressors, ensuring a more accurate assessment of holistic combat effectiveness.

THE GENERAL COMBAT LIFE CYCLE FRAMEWORK

Rather than simulating combat, this framework structures data collection to mirror combat's chronological arc, evaluating key physiological and cognitive functions. The General Combat Lifecycle Framework consists of multiple phases modelling the progression of a "troops-in-contact" event and seeks to test the physiological and cognitive functions most frequently employed by combatants.

- Phase 1–Patrol/Infiltration: Establishes baseline cognitive and physical capacity. Warfighters complete a Logical Memory Test (Wechsler's Memory Scale) followed by a Bruce Protocol to measure VO2 max, heart rate variability, and heart rate recovery, conducted in full combat gear. This simulates the physical requirements of an extended infiltration, and sets the conditions for to test working memory.
- Phase 2–Contact: Assesses rapid transition from steady-state exertion to high-intensity action. A weighted sled pull evaluates anaerobic capacity, maximum speed, and acceleration, followed by heart rate recovery assessment.
- Phase 3–Prosecution 1: Tests decision-making and marksmanship under stress. Warfighters engage in simulated shoot/no-shoot scenarios requiring threat prioritization and problem-solving. Biofeedback monitors physiological responses (e.g., eye tracking, heart rate, respiration) to analyze cognitive performance under duress. The simulation closely models a Go/No-Go and Psychomotor Vigilance Test for cognitive function. This phase measures visual perception speed, cognitive processing speed, shot accuracy, shot speed, shooting fundamentals, problem solving and other performance factors while simultaneously processing biofeedback data such as Heart Rate, Heart Rate Variability, Respiration Rate, Eye Tracking, Blood Pressure etc. to monitor the impact of physiological and psychological stress on tactical performance.
- . Phase 4–Contact 2: Replicates sustained combat task transitions by repeating the weighted sled pull assessment to gauge fatigue impact.
- Phase 5–Prosecution 2: Expands cognitive testing with dual-task performance. Warfighters receive complex instructions while engaging targets from varied shooting positions, testing adaptability and multitasking. This test incorporates the principles of Go/No-Go and Psychomotor Vigilance Tests, but adds in the element of a Dual-Task Performance Test.
- Phase 6–Reorganize: Evaluates post-engagement cognitive function. A second Logical Memory Test and Raven's Progressive Matrices test

assesses information retention and abstract reasoning following combat stress exposure.

DATA-COLLECTION AND ANALYSIS

Comprehensive Analysis: The Generalized Combat Lifecycle Framework exists as a structure within which to test to various aspects of combat readiness in relation to one another. Individual performance metrics and biofeedback measurements are captured as fractional data sets, and in the context of the Combat Lifecycle Framework can be collated into a "sum of components" to observe the interaction between data sets and articulate meaningful narratives. As a general example, instead of just capturing accuracy and reaction time alone, biofeedback data can be studied to determine the interaction between marksmanship performance and the presentation of physiological stress markers, measuring the influence of psychological or physiological factors on overall readiness. Cognitive and mechanical performance can be compared to physical performance to determine correlation, identify weaknesses in individual warfighter readiness, and measure the efficacy of existing training programs.

Example 1: A test subject observes a decline in his accuracy and consistency in response to simulated scenarios, and pressure pads in the employed rifle form factor and on the floor indicates poor shooting mechanics. Biofeedback data shows a consistently low HRV scores, and a low VO2 max. Further testing may illustrate that physical conditioning is impacting the warfighter's ability to employ mechanical skills effectively.

Example 2: A test subject is a 15-year special operator, who posts strong physical scores and average biomarkers, but performs poorly in reaction time, accuracy, problem solving during the scenario. Simulation performance is inconsistent with previous tests. Biofeedback analysis indicates a spike in stress markers during simulation portions. Logical Memory Test and Raven's Progressive Matrix tests also show reduced performance. Analysis could indicate a possible psychological issue or cognitive impairment. Further investigation indicates that the warfighter has recently suffered a contested divorce and is experiencing extreme emotion distress.

Combined Combat Readiness Score: Isolated data sets can also be combined as a "sum of components" to provide an objective measurement of universal combat readiness. Fractional data can be normalized, weighted and combined to provide a singular combat readiness score, which can be used to assess individuals in relation to their peer groups, or to measure unit readiness. Weights can be modified to reflect job-specific priorities. For instance, a special forces operational detachment would likely weight cognitive acuity more heavily against physical performance than a Marine infantry platoon, given the comparative complexity of their missions.

Tailorable Stimulus: Since the combat lifecycle is simply a framework to guide the relevant interaction of performance metrics, it can serve as a laboratory to test the impact of new conditioning/training regimens, equipment, and environmental stimulus. Simulated scenarios can also be tailored towards job-specific visual stimulus. The application of the framework as a combat performance laboratory will allow researchers and warfighters to study the comparative impact of a wide spectrum of variables on holistic combat readiness.

Example 1: A special operations unit preparing to for a winter deployment to northeastern Afghanistan exposes themselves to colder temperatures and reduced oxygen saturation independently to assess environmental impact on physicality, accuracy and cognitive acuity.

Example 2: A unit runs the Generalized Combat Lifecycle Framework assessment with a new optic to test its impact on overall performance. Analysis of data indicates a dramatic decrease in collective reaction time, and elevated stress biomarkers. Deeper analysis of performance shows consistent rifle presentation and mechanics, but slower shot time. Analysis and subsequent interviews reveal increased difficulty in sight-picture acquisition when compared to familiar equipment and suggests the requirement for equipment modification or additional training before new equipment is fielded.

Cognitive Coherency and Relationship to Consequence: Many law enforcement and military units have experimented with reactionary shock vests and sleaves for the purpose of education and stress inoculation. This capability can be integrated into the General Combat Lifecycle Framework as an additive stimulus to promote observation of psychological impact on performance. Error-induced physical pain would likely have an observable impact on cognitive acuity and overall performance in warfighters lacking self-efficacy. Additionally, an error-induced pain stimulus would identify, to a degree, which warfighters are inclined to fight through pain and maintain consistent composure.

CONCLUSION

To ensure warfighters are fully prepared for modern battlefields, assessment frameworks must evolve beyond isolated testing methods. The Generalized Combat Lifecycle Framework presents a solution by holistically integrating cognitive, physical, and psychological performance into a combat-relevant, measurable, and observable model. This approach enables precise evaluation and targeted training improvements, ultimately enhancing operational effectiveness and mission success. Furthermore, the Generalized Combat Lifecycle Framework can be used over the course of a warfighter's career to monitor not just relative performance, but the potential impact of prolonged exposure to stress, concussive blast, lifestyle changes, and heavy-metal exposure.