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Performance Enhancement in Aviation Expert Panel

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14. ABSTRACT

A webinar titled "Performance Enhancement in Aviation Expert Panel" occurred via Microsoft Teams on March 24, 2021. The webinar was sponsored by the U.S. Army Aeromedical Research Laboratory's Aeromedical Factors Team within the Warfighter Performance Group. Attendees included individuals from the following organizations: U.S. Army Aeromedical Research Laboratory, U.S. Army School of Aviation Medicine, U.S. Army Medical Center of Excellence, 8th Army, and U.S. Army Futures Command. The objective of the webinar was to identify a set of flight maneuvers/tasks/situations that present high workload, require high motor/cognitive/physical demand or precision, or are otherwise challenging for rotary-wing pilots of all skill levels. The resultant set of tasks will be used in performance enhancement research to be conducted in a simulator. Themes discussed during the panel were flight conditions, psychomotor flight tasks, executive function flight tasks, assessment, enhancement timing and administration, and fatigue.

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Summary

A webinar titled "Performance Enhancement in Aviation Expert Panel" occurred via Microsoft Teams on March 24, 2021. The webinar was sponsored by the U.S. Army Aeromedical Research Laboratory's Aeromedical Factors Team within the Warfighter Performance Group. Attendees included individuals from the following organizations: U.S. Army Aeromedical Research Laboratory, U.S. Army School of Aviation Medicine, U.S. Army Medical Center of Excellence, 8th Army, and U.S. Army Futures Command. The objective of the webinar was to identify a set of flight maneuvers/tasks/situations that present high workload, require high motor/cognitive/physical demand or precision, or are otherwise challenging for rotary-wing pilots of all skill levels. The resultant set of tasks will be used in performance enhancement research to be conducted in a simulator. Themes discussed during the panel were flight conditions, psychomotor flight tasks, executive function flight tasks, assessment, enhancement timing and administration, and fatigue.

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Introduction

As the Army modernizes and develops new technologies for aviators, the Army will inevitably develop systems that stretch the current capabilities of the aviation community. Research in the arena of Warfighter performance generally focuses on two areas of Warfighter enhancement: 1) the ability to preserve cognitive and/or physical ability while operating under suboptimal conditions (e.g., prolonged duty, poor sleep, degraded sensory input, hunger, muscular fatigue, etc.), and 2) the ability to enhance the normal cognitive or physical abilities of the Warfighter. Previous research shows the promise of pharmaceutical interventions (e.g., modafinil, dexamphetamine), nutritional interventions (e.g., ginseng), and technological interventions such as transcranial direct current stimulation (Kelley et al., 2019). The main limitation to the research is the lack of ecological validity due to the difficulty utilizing operational tasks in the lab. To move any intervention to the Warfighter, researchers need to establish effectiveness in the appropriate operational environments.

In an effort to bring the end user, the aviators, into the planning phase of research, the U.S. Army Aeromedical Research Laboratory (USAARL) convened a panel to identify challenging tasks and maneuvers in the aviation community that require high amounts of physical and/or cognitive demand. Within the military, aviators tend towards homogeneity in personality and ability; through self-selection into a potentially dangerous and difficult job, and through the higher standards of selection and training, pilots tend to score higher on executive function tasks (e.g., planning, critical thinking, attention monitoring, etc.) and tend to score higher on intelligence measures compared to general military members (Kratz et al., 2007). As enhancement techniques can be moderated by baseline ability (Randall et al., 2005), ceiling effects can present challenges for high functioning individuals- as may be the case with those who self-select and pass pilot training. That being said, it is important to conduct the research on various Warfighter subpopulations to understand which enhancement techniques are suitable and effective under what circumstances and for which type of Warfighter.

The ability to simulate the battlefield or a realistic operational environment is very difficult, yet extremely important in military research. Mission success and the lives of Soldiers may depend of the effectiveness of a prescribed intervention, so reducing the gap between in-laboratory testing and operational use needs to be a priority. Currently, USAARL researchers can modify aviators' workload in the lab within the UH-60 Black Hawk simulator in three main ways: 1) the external environment can be altered (e.g., visual conditions, weather, temperature, etc.), 2) the internal environment can be altered (e.g., difficult mission or flightpath, course changes, malfunctions in instruments or simulated helicopter, requiring night vision goggles (NVGs), multitasking requirements, etc.), or 3) the aviator's state can be altered by imposing operational stressors (e.g., fatigue, hunger, temperature in the cockpit, etc.). Varying any single or a combination of these factors can enable data collection to mirror many situations that challenge the capabilities and performance of military aviators, but, as is the purpose of this panel, researchers often lack the operational experience to develop ecologically valid tasks.

The main purpose of this panel discussion was to help ensure that the results of our research studies directly translate to functional performance and are reflective of the ever-changing battlefield conditions. The items identified from the panel are intended to guide future performance studies including performance enhancement. The following report serves as the

record of the webinar held on Microsoft Teams on March 24, 2021 by USAARL's Aeromedical Factors Team within the Warfighter Performance Group.

Objectives

The objectives of this panel were to: 1) identify a set of flight maneuvers/tasks/situations that present high workload, require high motor/cognitive/physical demand or precision, or are otherwise challenging for rotary-wing pilots of all skill levels; 2) identify aspects of performance that are measurable and meaningful to the maneuvers/tasks/situations; and 3) estimate the frequency of the maneuvers/tasks/situations. The primary outcome of the panel was a set of tasks (with relevant performance metrics) to be used in flight simulator-based performance enhancement research.

Expert Panel Structure

The panel facilitator presented an introduction to the panel covering an overview of performance enhancing research, task and conditions previously used in aviation related performance enhancing research, and the desired end stated of future research. Following the introduction, the panel engaged in a semi-structured discussion with 10 question serving as the focal point (see Appendix B). The following presents a summary of the themes, specific comments, suggestions, and recommendations from the panel members. To close, a discussion summarizing the panel is presented.

Attendees

A total of 15 individuals from six organizations participated the Performance Enhancement in Aviation Expert Panel (Table 1).

Table 1. Panel Attendees and Corresponding Organizations/Agencies

Position or Area of Expertise	Organization/Agency
Senior Scientist	U.S Army Aeromedical Research Laboratory
Research Psychologist	U.S Army Aeromedical Research Laboratory
Research Psychologist	U.S Army Aeromedical Research Laboratory
Research Pilot	U.S Army Aeromedical Research Laboratory
Research Psychologist	U.S Army Aeromedical Research Laboratory
Science Program Director	U.S Army Aeromedical Research Laboratory
Maintenance Officer	U.S. Army Aviation Center of Excellence
Chief Aviation Safety Officer	U.S Army Aeromedical Research Laboratory
Research Pilot	U.S Army Aeromedical Research Laboratory
Program Manager	U.S Army Aeromedical Research Laboratory
Company Commander (Pilot)	8th Army, Korea
Scientist	U.S. Army Medical Center of Excellence
Aviation Analyst	U.S. Army Futures Command
Flight Surgeon	U.S. Army School of Aviation Medicine

Discussion

The questions posed to the panel stimulated discussion of factors that contribute to elevated workload as well as how to best simulate operational stressors in the laboratory environment. The dialogue covered a wide range of topics for consideration including workload domain (cognitive, motor, etc.), the role of environmental conditions in elevating workload demands, specific challenging tasks and maneuvers, specific tasks that require a high level of sustained vigilance or attention, and individual preferences and differences. Examination of the comments provided yielded three emergent themes: environmental conditions that elevate workload, individual differences that contribute to workload, and specific tasks that require a high degree of attention or otherwise are challenging. We present these suggestions in Table 2, organized by theme. Note that comments were edited for redundancy and clarity.

Table 2. Emergent Themes and Comments Provided in Panel Discussion With Respect to High Workload Tasks and Conditions

Theme	**Comment/Suggestion**
Environmental Conditions	Ensure that studies feature both day and night flights under optimal and suboptimal/degraded conditions Tasks can be combined with degraded visual environment (DVE), take place over water, and be conducted in night conditions High gross weight environments
Individual Differences	Providing the pilot-participant with inexperienced co-pilots Skill levels including "stick and rudder," as well as cognitive and executive function abilities
Experimental Tasks	Combining tasks with unexpected emergencies Deck landings Flying with sling loads Flying within a confined space Dynamic aircraft performance updates Tasks that yield high physical (motor) and cognitive demands Future Vertical Lift (FVL) aircraft may present longer periods of flight requiring higher levels of sustained vigilance or workload Requiring an aviator to fly an aircraft in a manner that deviates from a standard profile The most critical phases of flight are takeoff and landing. Combining this with a DVE, over a body of water, or as a shipboard operation at night would be challenging

Additionally, the panel discussed the possibility of performance enhancement and optimization strategies including use of pharmaceuticals. Specifically, the panel members expressed the necessity for establishing procedures to ensure safety. Current research focused on enhancement often occurs in simulated flight and in a controlled environment. Laboratory settings enable much more control than what is found in operational unit, and proposed enhancement interventions must take this into consideration by assessing the impact of other substances (e.g., coffee, energy drinks, medications) and repeated exposure on the wellbeing of

the aviator. The logistics of introducing such interventions and how their utility and safety are impacted by real-world conditions are a key aspect of moving towards recommendations and application. Comments and suggestions are presented in the list below (note that comments were edited for redundancy and clarity):

- Researchers need to emphasize the inability of enhancement and optimization interventions to replace necessary rest and recovery, regardless of the effectiveness of the intervention.
- All other tools should be maximized prior to using pharmacological interventions, and if they are used, they are used with the understanding of downtime on the backside and if a mission is urgent then extra recovery must be provided post-mission.
- Research should also consider the post-intervention effects on aircrew and the possible effects from combining interventions with other commonly used items (e.g., energy drinks, stimulants, coffee).
- Guidelines need to be established that document how often enhancements can be used and how long of a time gap there needs to be to ensure safety between uses.
- After the efficacy and safety are demonstrated, research needs to establish which types of crews would be most benefitted by enhancement, whether the entire crew should use enhancement, whether the use of certain enhancements should be staggered, or whether only certain crewmembers should use enhancement.

Conclusions

USAARL's Aeromedical Factors Team conducted a virtual panel of experienced U.S. Army aviators in order to increase the ecological validity of simulated flight tasks employed in ongoing human factors research including performance enhancement research. Specifically, the team aimed to generate a set of tasks, flight conditions, and scenarios that yield high workload. Ensuring that aviators are physically and cognitively prepared for complex operations is imperative. Given data provided by the U.S. Army Combat Readiness Center, 75.8% of all Class A to C mishaps occurring over a ten year period (FY12-FY21) were related to human error (U.S. Army Combat Readiness Center, personal communication, October 21, 2021). During the discussion, three main themes emerged: environmental conditions, individual differences, specific tasks. The panel also discussed the possibility of implementation of performance enhancement interventions including the use of pharmaceuticals. Concerns regarding the influence of real-world conditions and maintenance of aircrew wellbeing were discussed and included scheduling guidelines, combined effects of caffeine use, and emphasis on the importance of sufficient rest and recovery following the use of enhancement measures. The comments provided by the panel will directly inform research objectives and methodology in human factors aviation research.

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Appendix A. Acronyms and Abbreviations

DVE	Degraded Visual Environment
FVL	Future Vertical Lift
NVG	Night Vision Goggles
U.S.	United States
USAARL	U.S. Army Aeromedical Research Laboratory

Appendix B. Discussion Questions

1. What are some common tasks/maneuvers associated with high cognitive demands?

2. What are some common tasks/maneuvers associated with high motor demands?

3. Multi-tasking can create high workload demands; what are some combinations of tasks/maneuvers that happen simultaneously and can be challenging to divide attention between?

4. Maintaining performance attention during periods of low demand can be equally taxing on operators/pilots. Can you speak to the duration of these sorts of "boring" stretches? How frequently do you encounter these periods of minimal input?

5. Fatigue in terms of sleep deprivation or chronic sleep deprivation is a well-known issue. What tasks are particularly challenging while fatigued?

6. Cognitive fatigue or overloading is a similarly well-known issue. Which tasks do you see as leading to cognitive fatigue? How does multitasking influence your performance when fatigued?

7. Can you speak to tasks that require a high degree of precision and that you have to pay very close attention to in order to accomplish?

8. During what tasks do you think you could use a "boost" in regards of performance?

9. In what conditions do you think you could use a "boost" in regards of performance?

10. Are there time points (time-on-task) in a mission where you would appreciate a "boost" in regards of performance?

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