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Interim Recommendations for Cognitive Enhancers for Future Vertical Lift Operators and Aircrew

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Background

The U.S. Army is modernizing its rotary-wing aircraft to the Future Vertical Lift (FVL) platform, which will likely yield higher cognitive workload for aircrew members and operators. Cognitive enhancement tools can be used to sustain attention and performance during long-duration flights and missions.

Research findings from a systematic literature review and experimental studies identified the efficacy of specific cognitive enhancement tools and its utilization in operational environments.

Systematic Literature Review Methods

A systematic literature review was conducted to determine the usage of cognitive enhancement tools in operational environments. The table below outlines the search criteria.

Criteria	Included	Excluded
Published	2008-2018	Any prior to 2008
Study Designs	Within-subjects placebo-controlled Between-subjects with control group	Non-random drug order Non-random assignment
Test Populations	Age: 18 to 50 years Race: Any Males and females Healthy Nationality: Any	Age: Under 18 years and over 50 years Race: None Gender: None Unhealthy or abnormal Nationality: None
Interventions	Modafinil Caffeine Pharmaceuticals Dopamine agonists Methylphenidate Exercise Nutrition Supplements Vitamins Training Mental strategies Transcranial stimulation	None
Language	English language	Non-English language
Outcome Measures	Measures valid and reliable Neuropsychological tests of cognition Measures of memory, attention, spatial reasoning, math reasoning, decision making, and judgment	Not validated Not tested for reliability Measures of mood, personality constructs, imaging studies

Systematic Literature Review Results

- A high degree of research supported the use of pharmaceuticals for attentional tasks. Findings show that effects are dosage- and time-dependent, results vary in selected tasks, and baseline performance determined the effects of enhancement performance.
- Transcranial electrical stimulation (tES) showed mixed effects on attention, working memory, and decision-making.
- Vitamin and herbal supplements enhanced effects on working memory tasks (e.g., word recall tasks) and information processing speed.
- Video games, aerobic exercise, and meditation will need further attention to determine the benefits of utilization and its effects.
- Pharmaceuticals and tES were evaluated by experimental studies at the U.S. Army Aeromedical Research Laboratory (USAARL) to evaluate the efficacy of these cognitive enhancing measures in military operations.

Experimental Study Methods

The USAARL conducted a pharmaceutical study comparing 200 milligrams (mg) Modafinil and 20 mg mixed amphetamine salts dosage while performing a military functional task, Patrol Exertion Task (figure1) and Standard Marksmanship Task (figures 2 and 3).

The USAARL conducted two studies utilizing tES to determine the success of enhancement in laboratory low-fidelity and high-fidelity simulation.

- Study 1 applied transcranial direct current stimulation (tDCS) to the left dorsolateral prefrontal cortex (figure 4) to enhance performance during cognitive and military tasks (Patrol Exertion Task and Standard Marksmanship Task). Potential secondary effects were documented post tDCS application.
- Study 2 utilized tDCS active and sham stimulation to evaluate the differences in aviators' performance, whether timing of stimulation significantly sustained attention and affected performance outcomes by delivering stimulation pre-flight and during-flight.



Figure 1. Patrol Exertion Task.

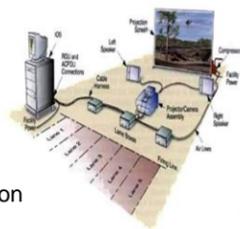


Figure 2. EST 2000 set-up.



Figure 3. Standard Marksmanship Task.

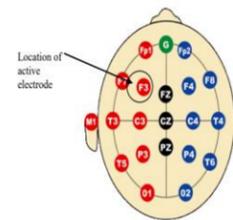


Figure 4. Electrode placement.

Experimental Study Results

USAARL Pharmaceutical Study

- The results determined that Modafinil enhance sustained attention. Effect was moderated by one's abstract reasoning with greater enhancement seen in those with lower abstract reasoning scores.
- Mixed amphetamine salts enhance functional performance and attention. Effects were moderated by one's abstract reasoning with greater enhancement seen in those with lower abstract reasoning scores.
- Few negative side effects reported following mixed amphetamine salts dosing (e.g., headache, dry mouth, and jitteriness). Four participants reported headaches following Modafinil dosing.

USAARL tDCS Studies

- Study 1 determined tDCS enhanced reaction time in cognitive performance task (e.g., Rapid Visual Information Processing [RVIP] and Shifting attention task). Active anodal and cathodal stimulation improved performance during Standard Marksmanship Task. Further research is needed to determine the difference individual factors that moderate performance.
- The results of study 2 found that tDCS improved flight performance and working memory during attentional tasks when stimulation is active during flight. This was important to determine whether tDCS can be used prescriptively during long duration flight missions that can tax attention in a high-performance operation.

Conclusion

- Cognitive enhancement tools is an ongoing research topic.
- The USAARL tDCS studies identified how tDCS can be used during long-duration missions where performance and attention needs to be maintained at high levels.
- Modafinil, mixed amphetamine salts, and tDCS are beneficial enhancement techniques.
- Other cognitive enhancement measures used by the military include caffeine, energy drinks, and cognitive training programs that are specific to occupational specialty.
- The USAARL is working on upcoming studies to further investigate the efficacy of cognitive enhancement tools:
 - Hyper-oxygenation and tDCS comparison for aviation enhancement
 - Donepezil drug study
- Constant monitoring of updated research literature, consistent communication within the area of research, and early planning for future Food and Drug Administration (FDA) approvals are imperative for new and ongoing research to be implemented.

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