

UNITED STATES ARMY AEROMEDICAL RESEARCH LABORATORY



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## Evaluating Operator State Using Eye Tracking and Pupillometry in Rotary-wing Pilots During Simulated Flight

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<b>14. ABSTRACT</b> Flight operations in degraded visual environments (DVE) pose significant risks to the aviators completing those operations. DVE occurs when an aviator is exposed to partial or total loss of visibility due to environmental factors, such as airborne dust, sand, or snow, as well as clouds, haze, fog, and starless nights. The implementation of advanced flight controls, sensors, and cueing delivered via the visual, auditory, and tactile senses has promise to mitigate the risk of accidents and mishaps in such conditions. U.S. Army Aeromedical Research Laboratory (USAARL) researchers recently completed a study evaluating the Integrated Cueing Environment (ICE) developed by U.S. Army Combat Capabilities Development Command researchers. Eye tracking was conducted to reveal how the pilot visually interacts with the symbology, and to assess arousal, autonomic tone, and potentially, cognitive workload, while they engage in the flight tasks. Presented at Aerospace Medicine Association's Annual Conference in 2023.					
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# Evaluating Operator State Using Eye Tracking and Pupillometry in Rotary-wing Pilots During Simulated Flight

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## Background

Flight operations in degraded visual environments (DVE) pose significant risks to the aviators completing those operations.

DVE occurs when an aviator is exposed to partial or total loss of visibility due to environmental factors, such as airborne dust, sand, or snow, as well as clouds, haze, fog, and starless nights.

The implementation of advanced flight controls, sensors, and cueing delivered via the visual, auditory, and tactile senses has promise to mitigate the risk of accidents and mishaps in such conditions.

U.S. Army Aeromedical Research Laboratory (USAARL) researchers recently completed a study evaluating the Integrated Cuing Environment (ICE) developed by U.S. Army Combat Capabilities Development Command researchers.

Eye tracking was conducted to reveal how the participant visually interacts with the symbology, and to assess arousal, autonomic tone, and potentially, cognitive workload, in aviators while they engage in the flight tasks.

## Methods

**Subjects:**  $n = 16$  U.S. Army-Rated Helicopter Pilots (500 Hour Minimum)

**Platform:** 2b-38 Six-Axis Full-Motion NUH-60M/L Black Hawk Simulator

**Avionics/Symbology:** Integrated Cuing Environment (ICE)

**Flight Route:** 12 Low Visibility, Nap-of-the-Earth, Flight Routes

**Mission Types:** Air Assault, Resupply, MEDEVAC

**Workload:** Induced by 1 of 4 task injections

**Cuing:** Visual (always present), Auditory (low or high sensitivity), Tactile (Tactical Situational Awareness System [TSAS]; low and high sensitivity).

**Eye Tracking (Pupillometry):** Pupil Labs Core Binocular Headset. 120 Hertz (Hz) Sample Rate per Eye at 400x400 Resolution. Forward Camera Sampled at 200 Hz at 1280x720 Resolution.

## Methods

Set A		Set B	
Label	Mission Type	Label	Mission Type
Route 1a	Air Assault	Route 1b	Air Assault
Route 2a	Resupply	Route 2b	Resupply
Route 3a	MEDEVAC	Route 3b	MEDEVAC

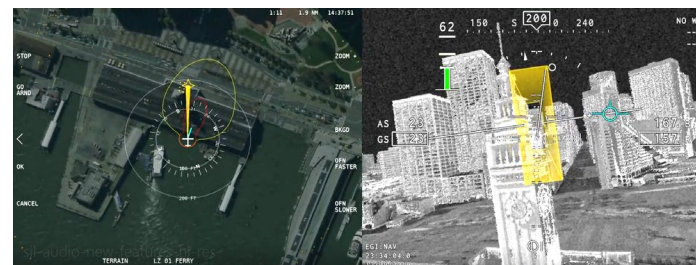
Condition Label	Auditory Manipulation	Tactile Manipulation
Condition 1	Low	Low
Condition 2	High	Low
Condition 3	Low	High
Condition 4	High	High



ICE Enroute Avionics



ICE Landing Avionics



ICE Overhead Map Display ICE Collision Avoidance Cuing



UH-60 Black Hawk Helicopter



NUH-60 Black Hawk Simulator

## Results

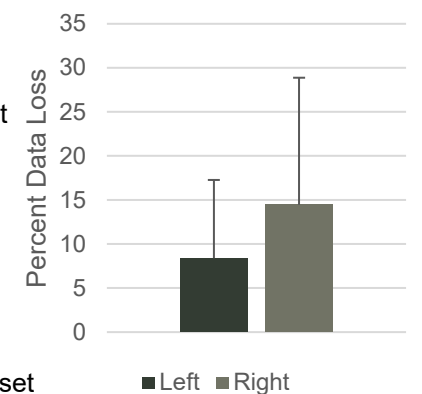


Pupil Labs, Pupil Core Binocular headset

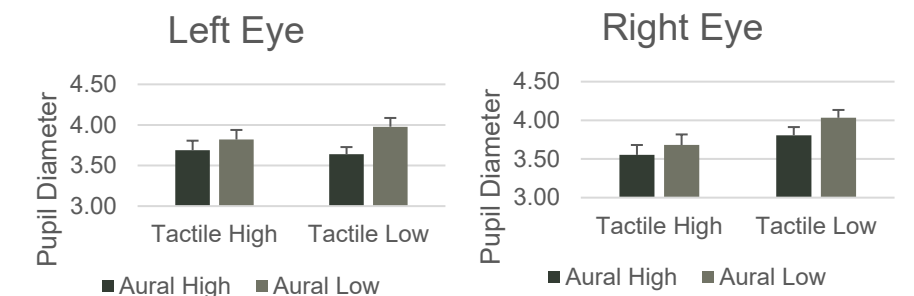


Biopac, B-Alert 2, and Pupil Core Headset

Average Data Loss Across All Subjects ( $n = 16$ )



Average Pupil Diameter and SEM by Cuing Sensitivity Across All Subjects ( $n = 16$ )



Tactile cueing sensitivity had a statistically significant effect on right eye pupil diameter at the 0.05 level ( $F = 6.579$ ,  $dfn = 1$ ,  $dfd = 164$ ,  $p = 0.011$ ).

Aural cueing sensitivity had a statistically significant effect on left eye pupil diameter at the 0.05 level ( $F = 4.670$ ,  $dfn = 1$ ,  $dfd = 164$ ,  $p = 0.032$ ).

## Discussion

These results suggest that more sensitive cueing is associated with a smaller average pupil diameter, suggesting a decrease in cognitive workload or decreased level of arousal.

This could indicate that increasing cueing sensitivity reduces workload, and the modality of cueing imposes a differential effect on the pupils which could be used to physiologically assess cueing salience in the aircraft.

Overall, these data support the utility of including eye tracking in future operator state monitoring solutions.

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## **U.S. Army Aeromedical Research Laboratory Fort Rucker, Alabama**

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