

DEPARTMENT OF
BEHAVIORAL SCIENCES AND LEADERSHIP

Effects of Fatigue and Training Strategy on UAV Simulator Performance

Lt Col Terence Andre (USAFA)

C1C Joshua Hunt (USAFA)

C1C Abigail Crews (USAFA)

Dr. Kevin Gluck (AFRL)



U.S. AIR FORCE



Overview

- **Introduction**
 - **Background, Research Objectives, Hypotheses**
- **Method**
 - **Participants, Apparatus, Procedure**
- **Results**
- **Discussion**
- **Conclusion**





Introduction

- **This study addresses the effectiveness of novice and expert flying training strategies and the potential effects of fatigue on performance**
- **Results will help in developing accurate cognitive models of UAV pilot performance**
 - **Applications will include development of training programs with computer-generated intelligent agents**



Background

■ Ops Tempo/Fatigue in UAV Operations

- Increased use of UAVs has led to varying shifts and extended duty days
- Ops tempo similar to deployed operators, yet UAV operators are still at “home”
 - Increased fatigue, emotional exhaustion and burnout (Thompson and Tvaryanas, 2006)
- Fatigue severely decreases mental performance
 - 5 hours of sleep for 2 weeks equates to same level of performance as 48 hours of sleep deprivation
 - Every 24 hour period of sleep loss equates to a 25-30% decrease in performance (Caldwell & Caldwell, 2005)





Background (cont'd)

- **Experts vs. Novices**
 - **Experts perform tasks systematically and in a more organized and efficient way than novice users (Linden et al., 2003)**
 - **Novices operate by trial and error and are more negatively effected by fatigue than experts (Linden et al., 2003)**





UAV Synthetic Task Environment





Research Objectives

- **Determine effects of novice and expert flying strategies on operator performance in UAV basic maneuvering tasks**
- **Examine the effects of fatigue on performance and its interactions with particular novice and expert UAV flying strategies**



Hypotheses

- **Hypothesis 1:**
 - **Participants given expert flying training strategies will perform better than those given novice flying training strategies**

- **Hypothesis 2:**
 - **Participants with more sleep will have better performance scores than those with less sleep**



Method

■ Participants

- **Random Sample of 41 Behavioral Science 110 (Introductory Psychology) students from the Air Force Academy**
- **All participants had less than 40 hours of flight experience**
- **All volunteers**
- **Compensated for participation with extra credit in their Behavioral Science 110 course**



Method

■ Apparatus

- UAV synthetic task environment on a Dell Dimension 8400, 3.4 GHz computer with two monitors, a stick, and throttle





Method

■ Apparatus (cont'd)

● Actigraphs (wrist mounted sleep monitor)

- Measures movement and acceleration to sense and record data such as circadian rhythms, sleep quality and total sleep time





Method

■ Apparatus (cont'd)


- Basic maneuvering tutorial to explain how to operate UAV in the simulated task environment

PREDATOR FLIGHT SCHOOL


Module 1 **Hand Controls**

Control Stick

The most important control is the stick. Pushing the stick to the left initiates a left-hand roll or bank (by deflecting the left aileron up, the airflow will push and spoil that wing down).



Control stick initiating roll maneuvers. Pushing the stick to the right will initiate a right-hand roll, while pushing stick to the left initiates a left-hand roll.



Control stick initiating pitch maneuvers. Pushing the stick forward will pitch the Predator down, while pulling the stick backward will pitch the Predator up.





Method

Training Strategies

■ Novice

- Focus only on performance instruments

■ Expert

- Focus on both control and performance instruments

Performance Instruments

Altitude

Heading

Airspeed

Control Instruments

Pitch

Bank Angle

Power (RPM)



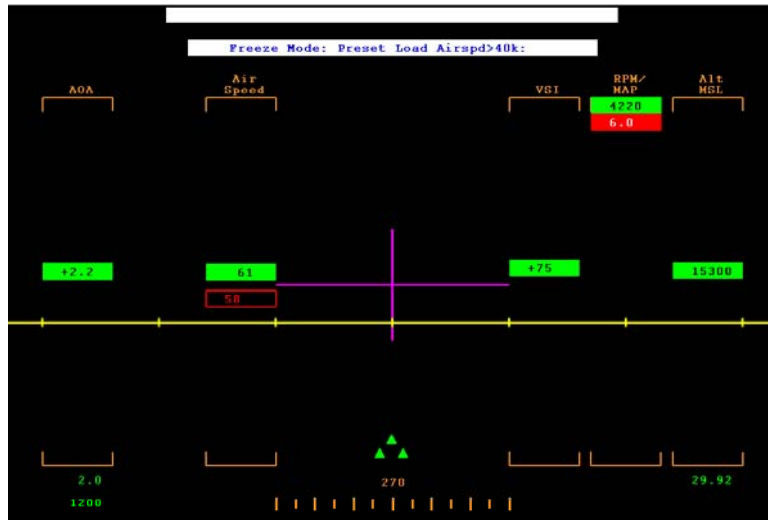
Method

■ Procedures

- **Prior to experiment participants completed a sleep survey used to separate into two groups with evenly distributed sleep habits**
 - **Surveyed**
 - Average bed time and average rise time
 - Average hours of sleep each night
- **Once separated into two groups, participants were given actigraphs**
 - **Informed to wear them at all times except for swimming and contact sports**
 - **Wore the actigraphs for the 4 days prior to their test date**
 - **Subjects recorded sleep times in a sleep log**



Method



TRIAL ARMED - PRESS TRIGGER WHEN READY

LEAD-IN TIME REMAINING: 10.0 seconds

1. HOLD STRAIGHT AND LEVEL UNTIL YOU HEAR THE BEEP, THEN:

2. CHANGE ALTITUDE, HEADING AND AIRSPEED :

CHANGE ALTITUDE FROM 15300 TO 15000 Feet
 CHANGE AIRSPEED FROM 62 TO 67 KIAS
 CHANGE HEADING, LEFT TURN FROM 270 TO 0 Degrees

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CURRENT LEG

90.0

TRIAL TIME REMAINING (s)

START	END
Altitude	Altitude
15300	15000
Airspeed	Airspeed
62	67
Heading	Heading
270	0
Bank Angle	

Frequency Control

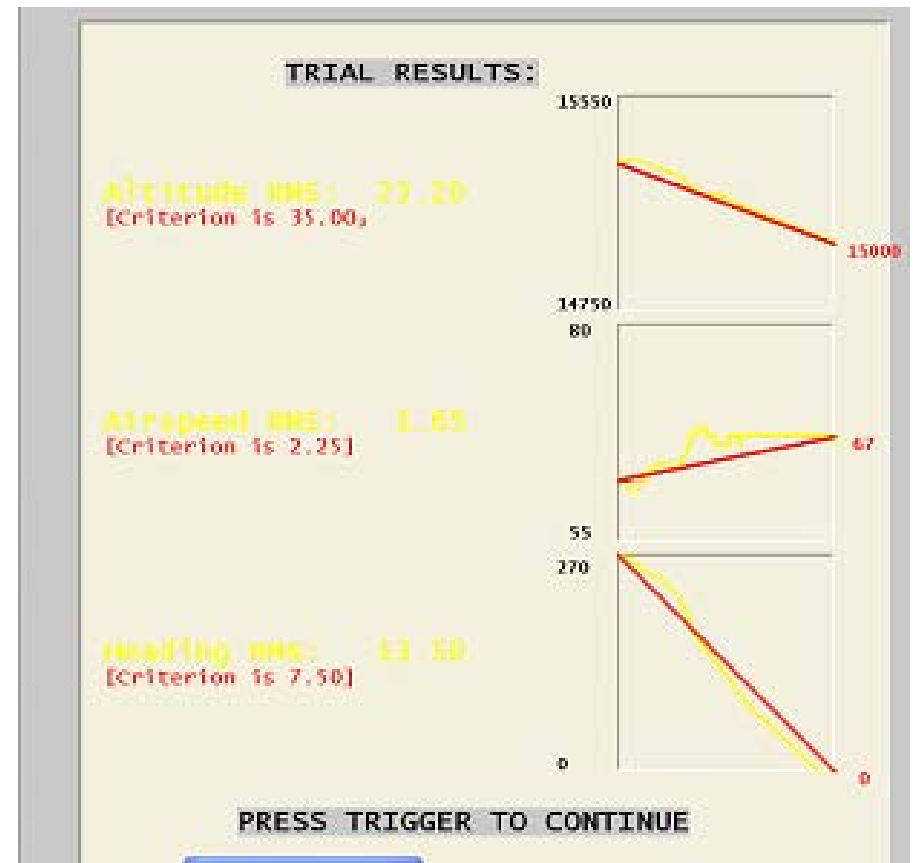
■ Procedures (cont'd)

1. Read and signed the informed consent document
2. Reviewed tutorial
3. Given novice or expert strategies depending on group
4. Completed 20 one and a half minute trials of the basic maneuvering task 7
 - Descend 300 feet
 - Turn left 270 degrees
 - Increase airspeed 5 knots



Results

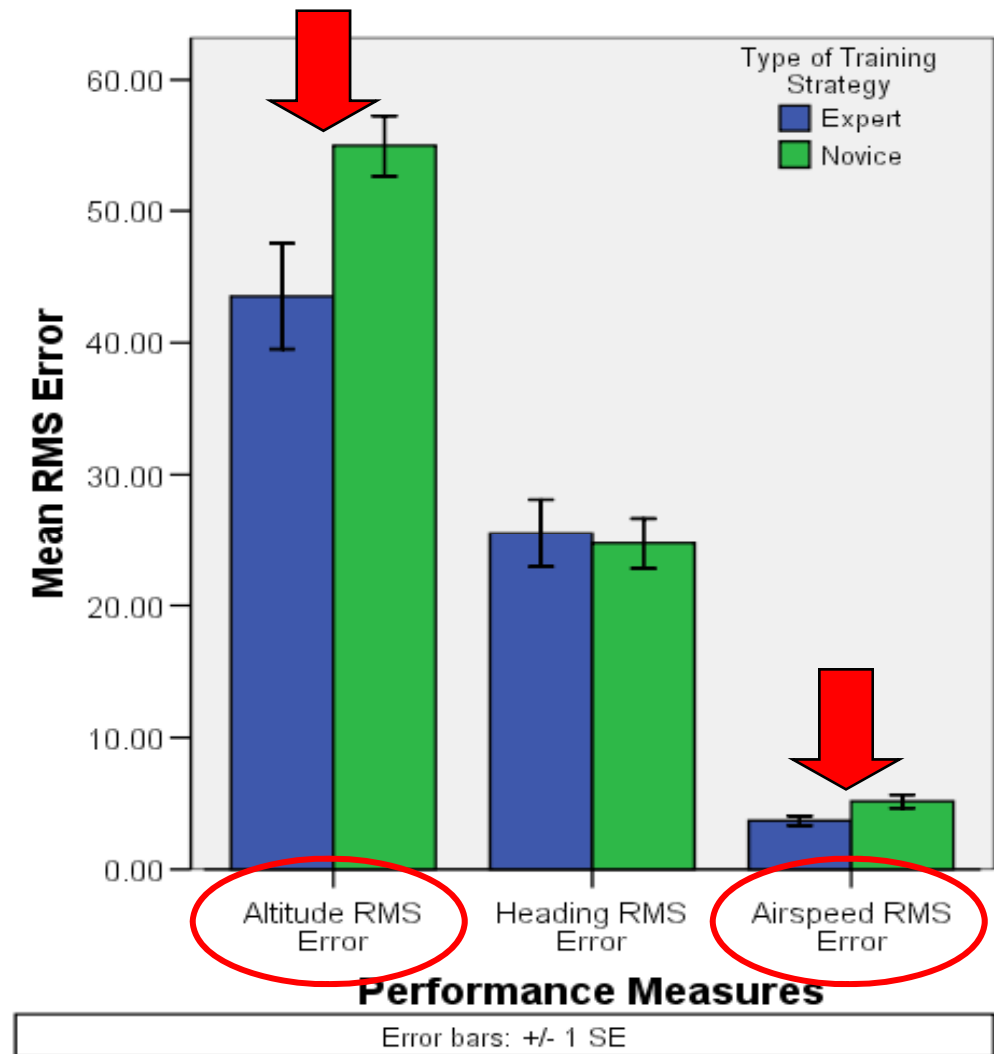
- Performance measured by Root Mean Squared (RMS) Error Analysis
 - Deviation from desired parameters
 - Altitude
 - Heading
 - Airspeed
- Lower RMS Error is better
- Results over the course of 20 trials were saved to subject files and transferred to Excel for analysis





Results – Training Strategy

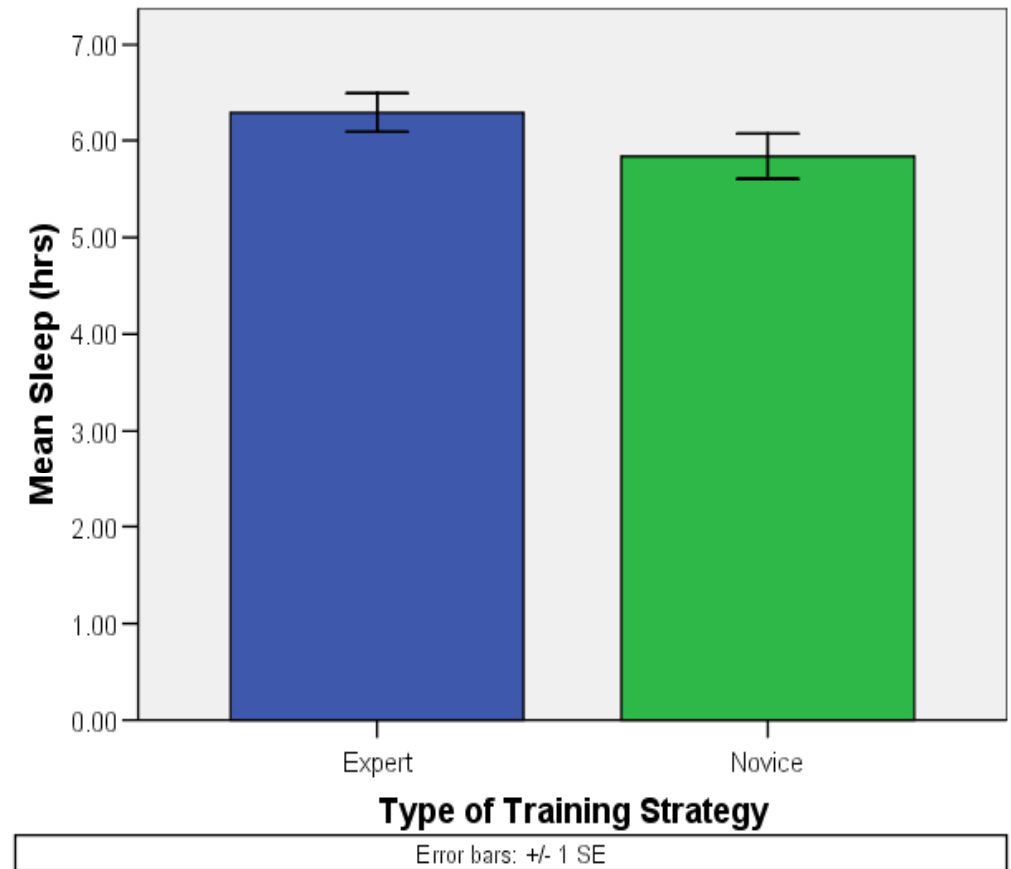
- Significant difference in Mean Altitude RMS Error [$F(1,39) = 6.208, p = .017$]
- Significant difference in Mean Airspeed RMS Error [$F(1,39) = 5.456, p = .025$]
- No significant difference in Mean Heading RMS Error [$F(1,39) = .060, p = .807$]





Results – Effects of Sleep

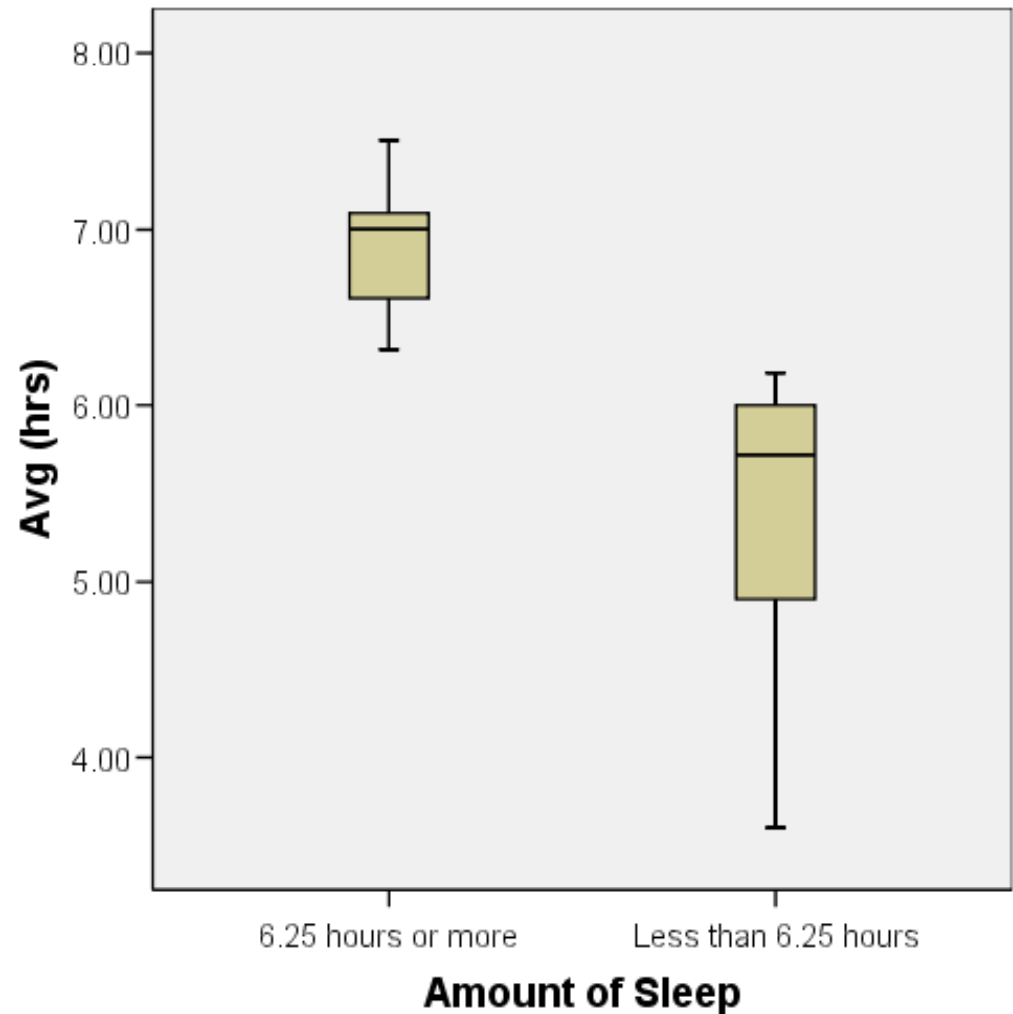
- Distributed sleep profiles evenly into two strategy groups using questionnaires
- Actigraph data collected when participants arrived at experiment
- Expert strategy group averaged 6.3 hrs of sleep while novice strategy group averaged 5.8 hrs of sleep ($p = .152$)
- Did sleep make a difference in terms of performance on task?





Results – Effects of Sleep

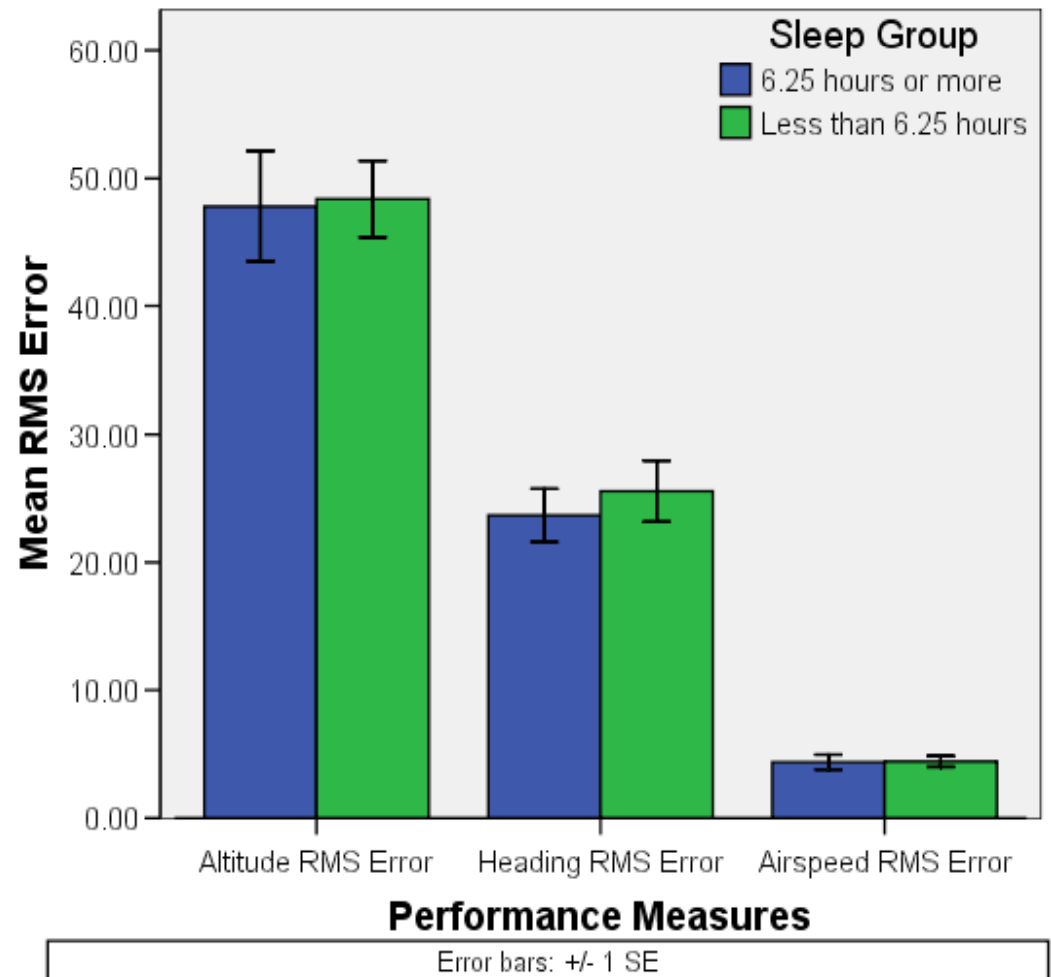
- Split participants by amount of sleep (actigraph data)
 - “Healthy sleepers”
≥ 6.25 hrs (Mean 6.87, SD .33)
 - “Unhealthy sleepers”
< 6.25 hrs (Mean 5.34, SD .77)





Results – Effects of Sleep

- Sleep did not significantly impact the performance measures
 - Altitude RMS error ($p > .10$)
 - Heading RMS error ($p > .10$)
 - Airspeed RMS error ($p > .10$)
- Average amount of sleep also did not impact performance measures as a covariate to training strategy ($p > .10$)





Discussion

■ Flying Training Strategy

- **Significant difference between expert and novice groups on altitude and airspeed control**
 - **Expert and novice strategies described altitude and airspeed control in very dissimilar ways**

- **No significant difference between groups on heading**
 - **In training strategies, heading was addressed as setting bank angle in both groups**



Discussion (cont'd)

■ Effects of Fatigue

- Fatigue did not have a significant impact on performance
- Many reasons fatigue may not have had an impact
 - Relatively homogenous population
 - Every participant had less than 8 hours of sleep (range 3.60 hrs to 7.50 hrs)
 - Thus, no real control group with “normal” sleep to compare against





Conclusions

- **Expert flying training strategies do in fact yield increased performance**
- **Fatigue did not impact results**

- **Future Research**
 - **Run study with a comparison group of “healthy sleepers” and those with “extreme sleep deprivation”**
 - **Compare UAV task performance data to civilian university to generalize findings of training strategies**



Questions?