Effects of Fatigue and Training Strategy on UAV Simulator Performance

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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 exahustion 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

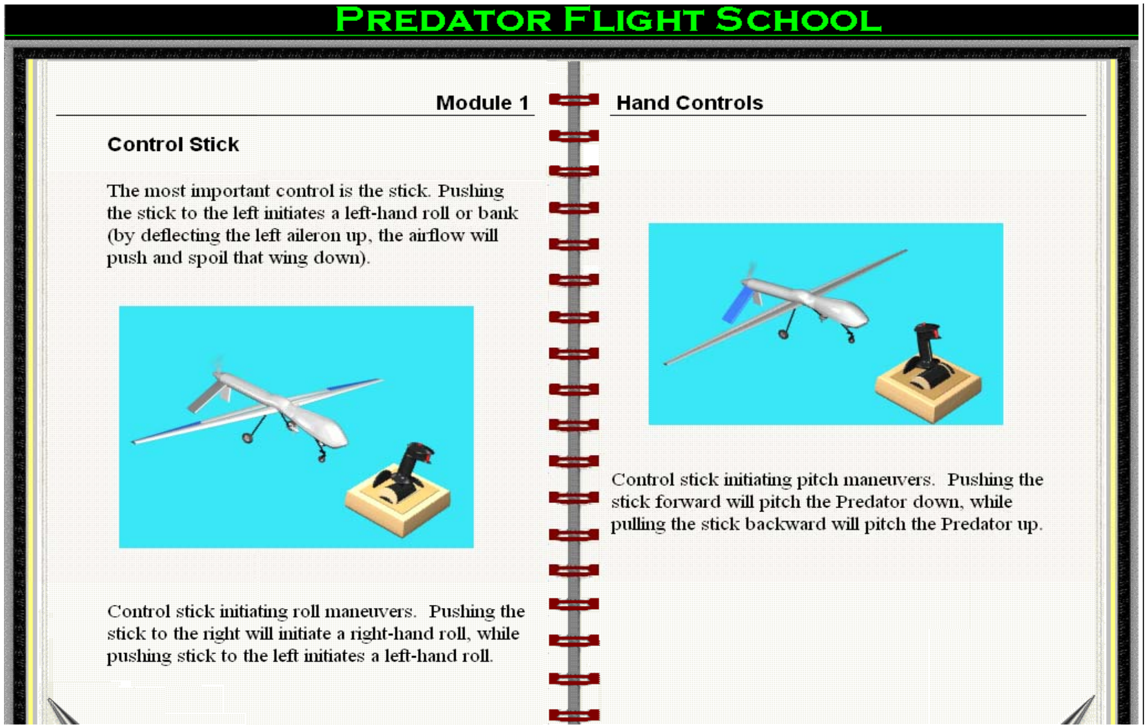
- **Apparatus**
  - **UAV synthetic task environment on a Dell Dimension 8400, 3.4 GHz computer with two monitors, a stick, and throttle**

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**



Method

Training Strategies

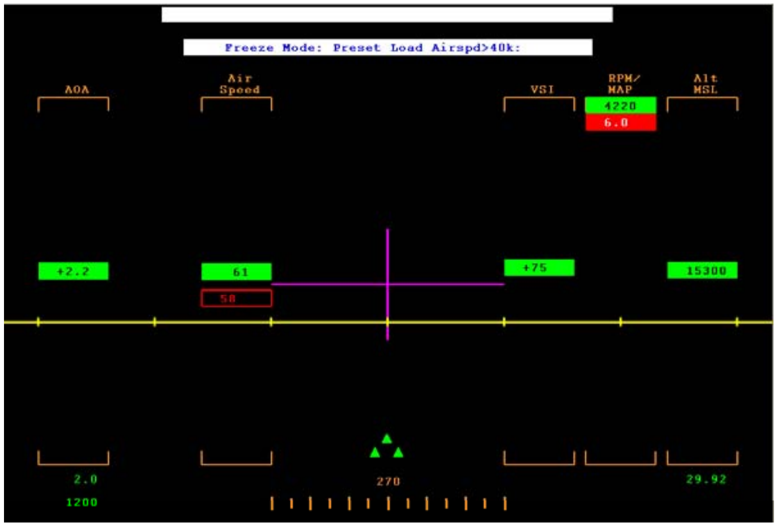
- Novice
  - Focus only on performance instruments
- Expert
  - Focus on both control and performance instruments

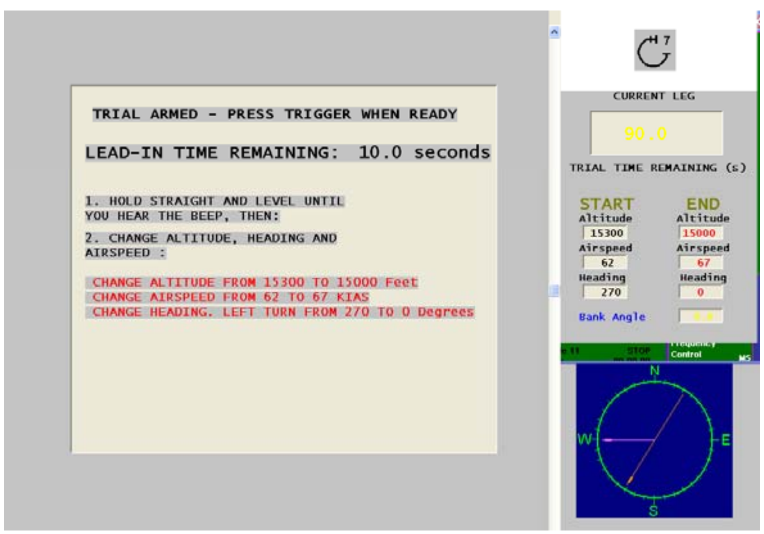
Performance Instruments	Control Instruments
Altitude	Pitch
Heading	Bank Angle
Airspeed	Power (RPM)

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

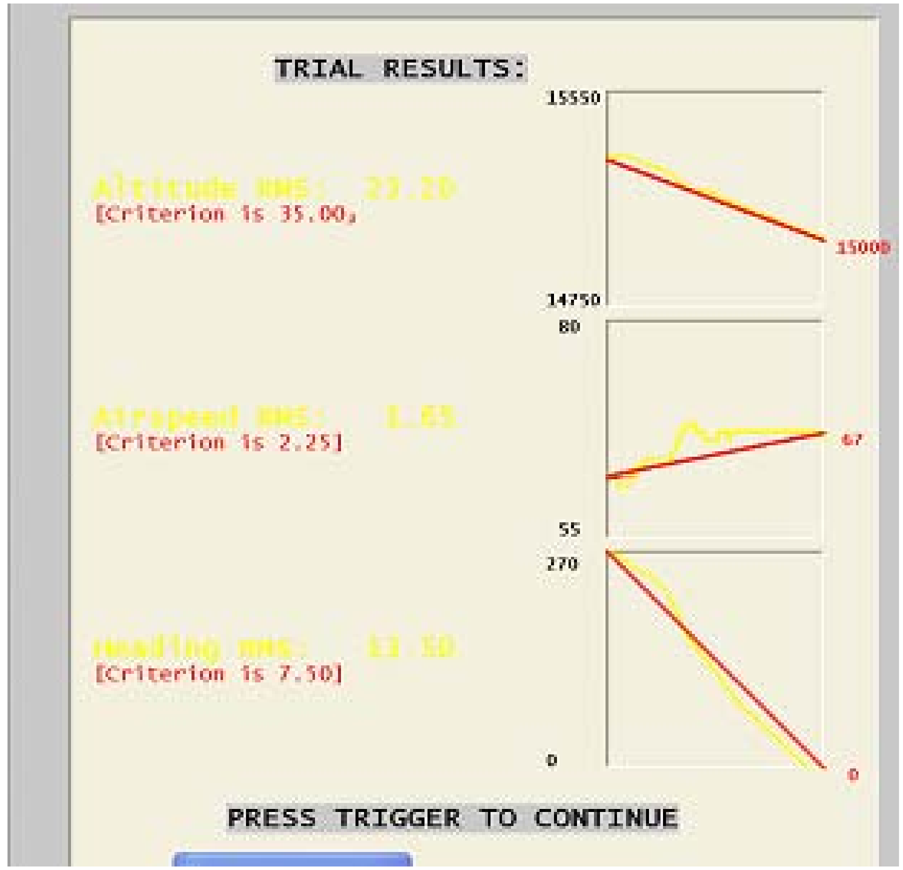




- Procedures (cont'd)
  1. Read and signed the informed consent document
  2. Reviewed tutorial
  3. Given novice or expert strategies depending on group
  4. Completed 20 one and a half minute trials of the basic maneuvering task 7
     - Descend 300 feet
     - Turn left 270 degrees
     - Increase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

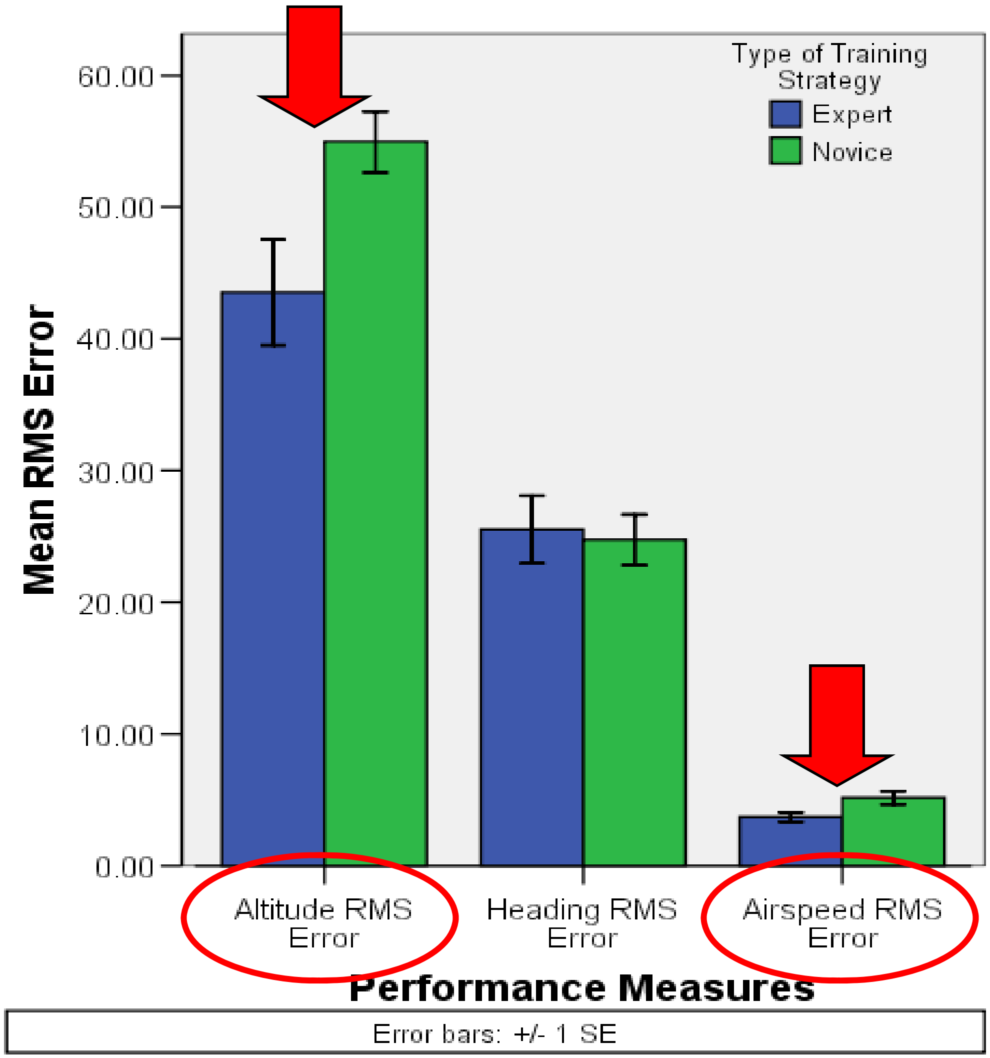
Results

- 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



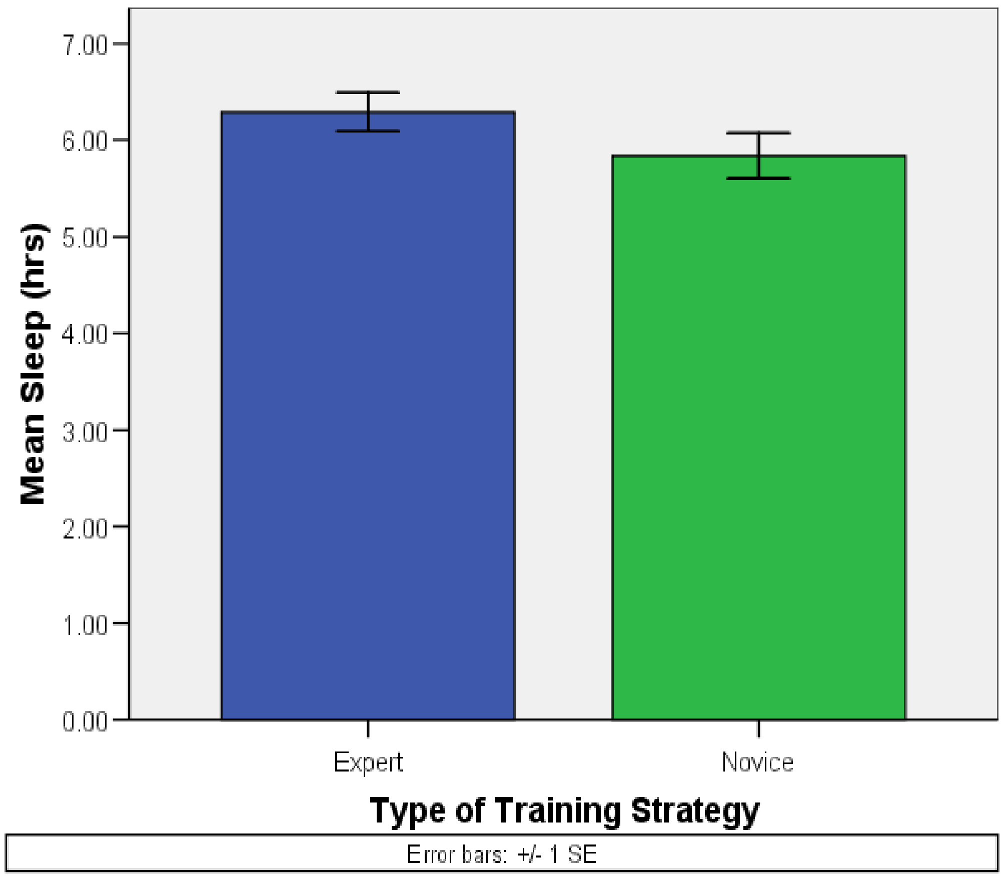
Results – Training Strategy

- 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?

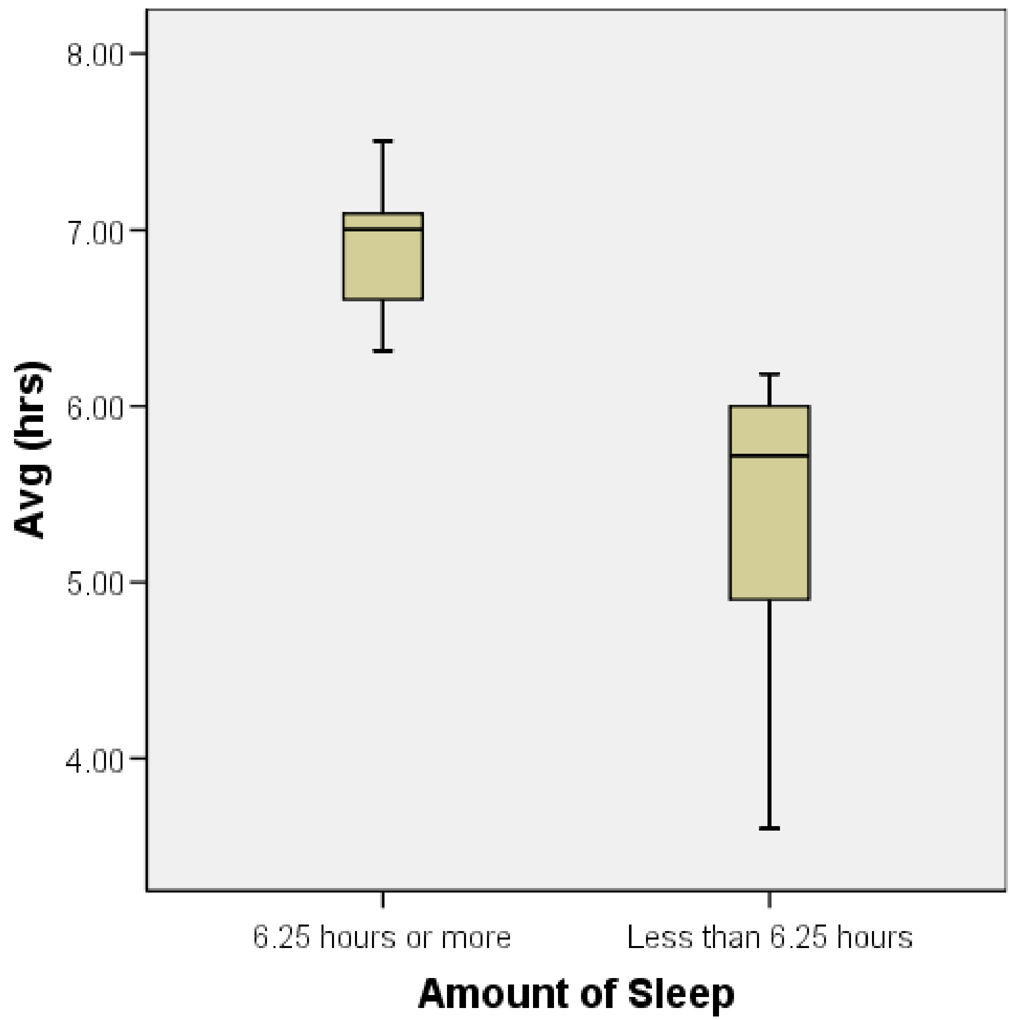


Results – Effects of Sleep

- Split participants by amount of sleep (actigraph data)
  - "Healthy sleepers"

  ≥ 6.25 hrs (Mean 6.87, SD .33)
  - "Unhealthy sleepers"

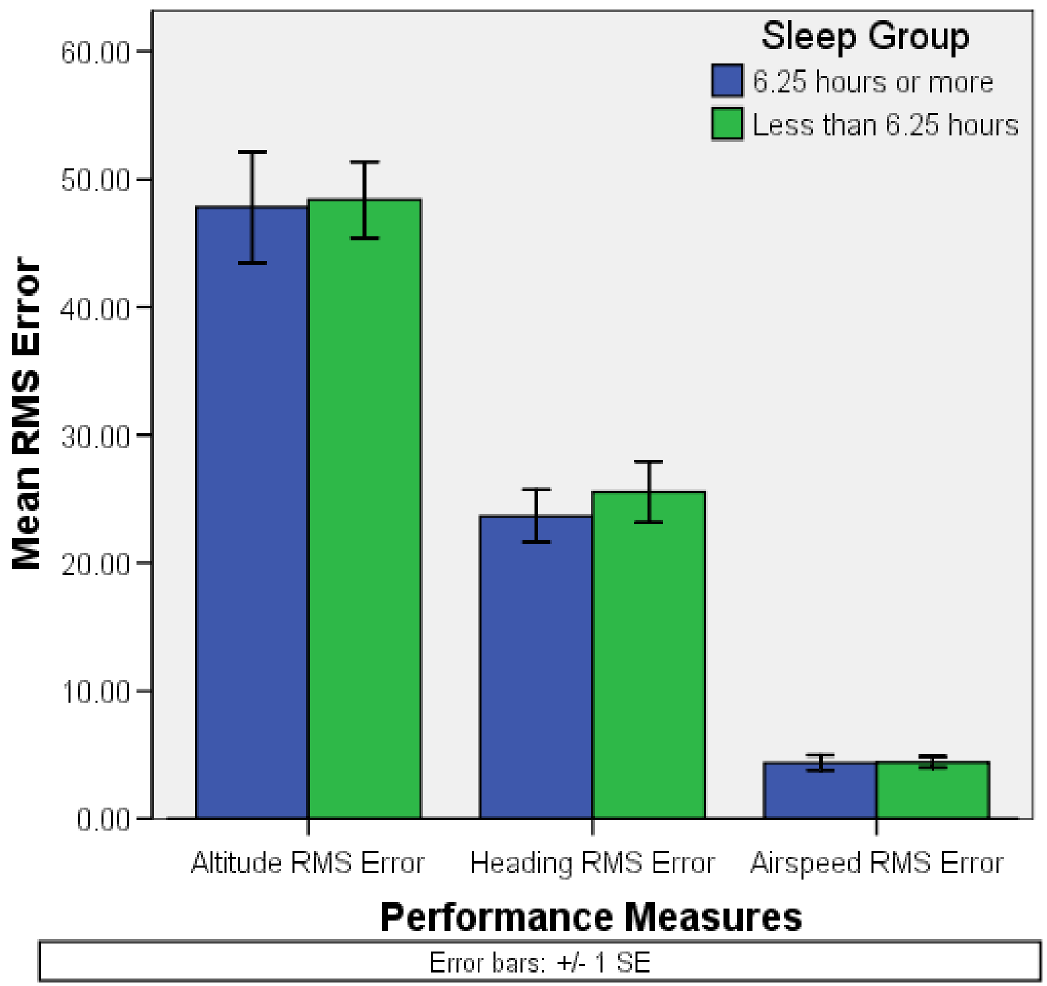
  < 6.25 hrs (Mean 5.34, SD .77)



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?