Efficacy of Directional Tactile Cues for Target Orientation in Helicopter Extractions over Moving Targets

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Background

- Rescue hoist flight operations
  - Maintain stabilized hover over targets
  - Very difficult task especially in situations of limited contrast (e.g., over water, desert, and snow)
  - Requires constant control adjustments
  - To make adjustments, must rely on verbal instructions of non-flying crewmember and limited visual cues (cannot see below aircraft)
- Any method that accelerates the extraction process may result in quicker medical care for injured, hypothermic, or drowning persons
Tactile Situation Awareness System (TSAS)

- Provides information via sense of touch
- Modified version, TSAS-Lite, consists of tactors in a belt, shoulder harness, and seat cushion
- TSAS-Lite $ TSAS improves pilot perception of drift and SA


Objective

• To evaluate the efficacy of TSAS-Lite for target orientation in helicopter extractions over moving targets
  – Varied conditions including fatigue/rested, clear/degraded visual environment, amount of training
• Hypothesis: Pilots would be more efficient at maintaining their position over a moving target when equipped versus not equipped with the TSAS-Lite belt
Design and Participants

• Mixed-model factorial design
  – Within-subjects Independent Variable:
    • State (rested, fatigued)
    • TSAS-Lite belt (active, inactive)
    • Visual environment (clear, degraded)
  – Between-subjects Independent Variable:
    • Training amount (minimal, additional)

• 16 UH-60 rated, healthy aviators
  – Age: $M = 33$ years ($SD = 8.65$)
  – 14 males
  – 13 US Army Active-Duty (3 other US Army components)
Materials

- **Fatigue**
  - Psychomotor vigilance task (PVT)

- **Workload and SA**
  - Post-flight questionnaire (visual analogue scale)
  - China Lake SA scale (CLSA)

- **Flight simulator**
  - UH-60 research flight simulator
  - Key flight parameter dependent variable was range (ft) of the “helicopter” from target (target range)
Materials, cont.

• Tactile system
  – TSAS-Lite belt (2 tactors in shoulder harness and 6 in seat cushion)
  – Tactors placed every 45 degrees in belt (8 tactors)

Belt worn by aviator                Inside view of belt.
Procedure

• Day 1 - In processing, training, data collection
  - Minimal training = One 60 minute session
  - Additional training = additional 60 minute sessions
  - Data collection: Four 10-minute stabilized hovering maneuvers (at 70 feet above ground level), PVT, and questionnaires
    • 4 test conditions
      – TSAS active and good visual
      – TSAS active and degraded visual
      – TSAS inactive and good visual
      – TSAS inactive and degraded visual

• Day 2 – One night of sleep deprivation, data collection
Simulated flying to a ship where the helicopter landing deck was used as the moving target
Analysis

• A mixed-model ANOVA - to evaluate the effects of state, training amount, visual environment, and TSAS-Lite on range of helicopter from target during hover.

• A mixed-model ANOVA - to determine the effects of the independent variables on range during the visual distraction segment of the flight.

• A principal components analysis (PCA) - to determine what, if any, linear combinations of tactor positions existed (strategy by pilot to use tactor information) with respect to the stimulus intensity data recorded per observation.
Results - Fatigue

• PVT data
  – Significantly slower reaction times when fatigued versus rested, $t(15) = -3.408, p = 0.004$
  – Significantly more lapses (responses greater than 500 ms) when fatigued versus rested, $t(15) = -5.074, p < 0.001$
Results – Post flight and SA questionnaires

• Repeated measures MANOVA
  – Participants rated SA as better when TSAS was active versus inactive
  – Participants rated workload as greater when fatigued versus rested
  – Participants rated SA as worse when visual environment was degraded versus clear
Results – Flight performance

- Mixed Model ANOVA
  - Main effects of visual environment and TSAS-Lite
  - Performance was better when visual environment was clear versus degraded
  - Performance was better when TSAS-Lite was active versus inactive
Results - Tactors

- Greatest proportion of stimuli fired from back tactor
Results, tactors cont.

- Some participants developed a strategy of using the tactors to reduce the risk of the rotor blades striking the two shipboard antennae located in front of the aircraft on both the left and right side.

- Principal Components Analysis
  - Composite tactor scores
  - 3 components
    - 1\textsuperscript{st} component – Contrast of back to left tactors
    - 2\textsuperscript{nd} component – combination of right tactors
    - 3\textsuperscript{rd} component – contrast of front to back-left tactors
Discussion

• Pilots were able to safely maintain a closer position to target when TSAS-Lite was active
• Data patterns indicate that participants developed strategy for using the cues
• Measures of fatigue and questionnaires served as manipulation check
  – Suggest manipulations were effective (fatigue and visual degraded environment)
Future Research

• Perform in-flight degraded visual environment tests which recording pilot gaze and pilot inputs to controls
  – Evaluate whether TSAS-Lite reduced pilot workload and improves performance

• Conduct experiments to demonstrate the role of the TSAS-Lite belt in reducing pilot fatigue during long duration flights

• Determine the optimal amount of TSAS-Lite belt training time to most effectively prepare pilots to use TSAS
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