Training Simulation for Helicopter Navigation by Characterizing Visual Scan Patterns

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Introduction: Helicopter overland navigation is a cognitively complex task that requires continuous monitoring of system and environment parameters and years of training. This study investigated potential improvements to training simulation by analyzing the influences of flight expertise on visual scan patterns. ***Methods:*** There were 12 military officers who varied in flight expertise as defined by total flight hours who participated in overland navigation tasks. Their gaze parameters were tracked via two eye tracking systems while subjects were looking at out-the-window (OTW) and topographic Map views in a fixed based helicopter simulator. ***Results:*** Flight performance measures were not predicted by the expertise level of pilots. However, gaze parameters and scan management skills were predicted by the expertise level. For every additional 1000 flight hours, on average, the model predicted the median dwell will decrease 28 ms and the number of view changes will increase 33 times. However, more experienced pilots scanned more OTW than novice pilots, which was contrary to our expectation. A visualization tool (FEST: Flight and Eye Scan visualization Tool) to replay navigation tasks and corresponding gaze data was developed. Qualitative analysis from FEST revealed visual scan patterns of expert pilots not only looking ahead on the map, but also revisiting areas on the map they just flew over to retain confidence in their orientation. ***Discussion:*** Based on the analysis provided above, this work demonstrates that neurophysiological markers, such as eye movements, can be used to indicate the aspects of a trainee's cognitive state that are useful for cuing an instructional system.

Keywords: expertise, gaze, terrain association, cognition.

HELICOPTER OVERLAND navigation is a complex task that normally is assigned to the nonflying pilot, who is responsible for providing verbal instructions to the flying pilot to reach navigation checkpoints. As described in Wright (23), navigation is never the sole aim of a mission. In addition to navigation, pilots are required to complete a higher level task such as logistics support, intelligence, surveillance and reconnaissance, or combat search and rescue. The nonflying pilot has additional responsibilities, including terrain and obstacle avoidance, monitoring and managing engine and system performance, and communications. Consequently, skilled pilots oftentimes stay off-track intentionally to stay oriented or to achieve a higher level task. In this particular case, a high root mean square (RMS) error of flight trajectory, a commonly used performance measure, does not necessarily indicate a pilot's poor performance. Rather, it is a result of a pilot's ability to monitor key environmental parameters. This ability is accrued through extensive helicopter overland navigation training.

During helicopter overland navigation training, instructors often face the dilemma of knowing when and how to provide the best feedback to the student. Busy flying in a challenging environment, avoiding terrain and obstacles, the instructor has few opportunities to understand what mistakes were made by the student, when the mistakes were made, and how to explain those mistakes to the student to provide an opportunity to learn from them, all within a few minutes of the mistake being made. When a student deviates from the planned course, the instructor is missing critical information to maximize the learning potential of the real training opportunity, that of the student's cognitive state.

In order to provide the best feedback to the student in the right form at the right time, the instructor pilot needs to know the student's cognitive state. Currently, observing the student's cognitive state is guesswork and there are few real-time cues available for the instructor to assess how the student monitors key parameters, perceives flight routes, and implements navigation strategies. We investigated whether visual scan differences between expert and novice pilots in helicopter navigation tasks could act as a useful cue to indicate student's cognitive states and aid navigation instruction. If visual scan measures provide us some estimates on students' cognitive states and if there exist differences in scan patterns between different expertise levels, our study suggests that providing real-time eye scan data can be a potential method to enhance helicopter navigation training.

A common goal in training research is to train novices to behave and think like experts (11). It is known that pilots with more flight experience consistently perform better on aspects of flight control than those with less experience (1,10,20). When making aviation-related decisions, experts described more elaborate scenario problems than novices, indicating greater depth of understanding of the issues (14). As stated above, helicopter

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