RESEARCH ARTICLE

Pilot Performance: Assessing How Scan Patterns & Navigational Assessments Vary by Flight Expertise

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Introduction: Helicopter overland navigation is a cognitively complex task that requires continuous monitoring of system and environmental parameters and many hours of training to master. This study investigated the effect of expertise on pilots' gaze measurements, navigation accuracy, and subjective assessment of their navigation accuracy in overland navigation on easy and difficult routes. ***Methods:*** A simulated overland task was completed by 12 military officers who ranged in flight experience as measured by total flight hours (TFH). They first studied a map of a route that included both easy and difficult route sections, and then had to 'fly' this simulated route in a fixed-base helicopter simulator. They also completed pre-task estimations and post-task assessments of the navigational difficulty of the transit to each waypoint in the route. Their scan pattern was tracked via eye tracking systems, which captured both the subject's out-the-window (OTW) and topographical map scan data. ***Results:*** TFH was not associated with navigation accuracy or root mean square (RMS) error for any route section. For the easy routes, experts spent less time scanning out the window ($\rho = -0.61$) and had shorter OTW dwell ($\rho = -0.66$). For the difficult routes, experts appeared to slow down their scan by spending as much time scanning out the window as the novices while also having fewer Map fixations ($\rho = -0.65$) and shorter OTW dwell ($\rho = -0.69$). However, TFH was not significantly correlated with more accurate estimates of route difficulty. ***Discussion:*** This study found that TFH did not predict navigation accuracy or subjective assessment, but was correlated with some gaze parameters.
Keywords: expertise, scan strategy, cognition, subjective assessment.

A COMMON GOAL IN training is to teach novices to behave and think like experts so that they can more quickly attain satisfactory levels of performance and decision-making skills (10). In aviation, performance is generally assessed by level of flight control, typically defined by root mean square (RMS) error of flight trajectory, accuracy of flight decisions, and depth of understanding of the issues surrounding the decision. Expert pilots, defined by total flight hours or FAA ratings, consistently perform these tasks better than less experienced pilots (1,9,12). Helicopter overland navigation is a particularly challenging aviation task for trainees and instructors as it entails additional cognitively demanding tasks above and beyond flight control. Furthermore, RMS error of flight trajectory does not predict expertise levels in helicopter overland navigation (15) as it does in other aviation tasks. This is because helicopter pilots are trained to adapt their between-waypoints navigation solution based on current observation. For example, pilots may elect to deviate from a straight-line connection between waypoints to take advantage of a guiding feature that was not readily apparent in preflight planning (15). Thus, in training helicopter pilots, a different measure of expertise beyond RMS error is needed.

Another limitation of using RMS error as a measure of flight expertise is that it does not provide information regarding experts' underlying cognitive strategies while flying or how these strategies may change with accrued experience. Currently, little is known about the learning process underlying improvements in flight control and navigation. For example, do experts simply demonstrate more precise control or do they do things in a qualitatively different way, by perhaps sampling different sources of information (1,7)? In order to better explain why pilots' overland navigation accuracy differ by expertise level and to find cues for assessing their cognitive states, we suggest observing human behaviors (e.g., where they look) which influence their performance (e.g., how they navigate). Even for one of the most common causes of mishaps, the breakdown in cockpit scan, developing a good scan strategy has not been given high priority during training (2). Standardized methods and scan patterns can be described to students at a high level and in general terms; however, actually assessing the appropriateness of a student's scan in relation to the in-situ training environment and their performance is not well supported. There is little support for instructors to provide carefully tailored feedback specific to a pilot and the immediate training environment. Thus, the purpose of this study was to attempt to understand underlying cognitive strategies used by experts that aid in superior performance.

The goal of our research is to improve training in challenging aviation tasks by providing instructors with real-time information regarding what the trainee is thinking. A large body of research demonstrates that eye scan parameters successfully predict different cognitive states, and we have found it to be able to detect an underlying cognitive strategy specific to overland navigation. Although navigation performance provides a

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