Helicopter Pilot Scan Techniques During Low-Altitude High-Speed Flight

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Introduction: This study examined pilots' visual scan patterns during a simulated high-speed, low-level flight and how their scan rates related to flight performance. As helicopters become faster and more agile, pilots are expected to navigate at low altitudes while traveling at high speeds. A pilot's ability to interpret information from a combination of visual sources determines not only mission success, but also aircraft and crew survival. ***Methods:*** In a fixed-base helicopter simulator modeled after the U.S. Navy's MH-60S, 17 active-duty Navy helicopter pilots with varying total flight times flew and navigated through a simulated southern Californian desert course. Pilots' scan rate and fixation locations were monitored using an eye-tracking system while they flew through the course. Flight parameters, including altitude, were recorded using the simulator's recording system. ***Results:*** Experienced pilots with more than 1000 total flight hours better maintained a constant altitude (mean altitude deviation = 48.52 ft, SD = 31.78) than less experienced pilots (mean altitude deviation = 73.03 ft, SD = 10.61) and differed in some aspects of their visual scans. They spent more time looking at the instrument display and less time looking out the window (OTW) than less experienced pilots. Looking OTW was associated with less consistency in maintaining altitude. ***Discussion:*** Results may aid training effectiveness specific to helicopter aviation, particularly in high-speed low-level flight conditions.

Keywords: visual scan, low level flight, expertise, helicopter.

FOR HELICOPTERS, flying at high speeds and low levels is not the safest way to fly, but in times of war, it may be necessary for survival. A helicopter's primary means of defense while flying in combat is to remain low and masked by the terrain. Maintaining high speeds is vital for reducing the time an enemy has to target the helicopter as it passes overhead.

The ability of a pilot to interpret information from a combination of sources while operating in the demanding low-level flight environment determines the success of a mission as well as crew and aircraft survival. These sources include the outside environment, the instrument panel, displays that inform the pilot of the aircraft's status, and additional information from navigation charts or global positioning system displays. Competent pilots can move their scan from source to source in a way that maximizes the assimilation of information and react accordingly to safely maneuver the aircraft. The purpose of this study was to begin to understand the visual scan patterns used by active duty military helicopter pilots during a simulated low-level high-speed flight scenario.

Previous research has demonstrated that eye-tracking technology can successfully detect pilots' visual scan patterns. Bellenkes et al. (1) measured attention control by analyzing the visual scanning behavior in expert and novice pilots during a simulated visual flight rules flight. Experts scanned the flight instruments, particularly the directional gyro and altimeter, more often than novices. Novices dwelled longer, on average, than experts, particularly on the vertical speed indicator and turn coordinator. As expected, experts performed better than novices in terms of altitude control, particularly on the two most difficult segments of the route.

The association between visual scan patterns and flight performance was investigated by Karsarkis et al. (2), who suggested that the focus on airspeed is a key strategy—this strategy was particularly evident during change in flight altitude. Results also revealed that experts had shorter dwells on all areas of interest, indicating automation (when a pilot is 'locked in' to a scan pattern and does not deviate from it), and that the experts had more time to scan other locations. Importantly, more fixations and shorter dwell times were also associated with good landings, suggesting that these visual strategies cause expertise differences in landing performance. Ottati et al. (5) extended these results (1,2) to test the hypothesis that expert pilots spend less time finding and fixating on individual landmarks, and are able to use landmarks to navigate more accurately than novice pilots. The authors concluded that novice pilots are more likely to use spontaneous fixations (a pilot fixates on an event that is outside of the task they are currently presented with) during flight tasks to gain an accurate orientation.

These studies demonstrate that learned differences exist in visual scanning patterns and some evidence suggests that certain visual scan patterns are associated with better flight performance. However, these studies focus on the scanning patterns of fixed wing pilots. Few studies have investigated pilots' visual scan patterns during a low-level en-route flight in a helicopter. Sanders et al. (6) examined the visual workload of the

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