Analysis of Pilot’s Visual Scanning Characteristics under Normal and Extreme Flight Conditions

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Abstract: Pilots must effectively scan the necessary instruments in flight deck from the moment that the airplane takeoffs until it safely lands. A small scale experiment was performed to investigate whether the visual scan characteristics would differ between novice and expert pilots under normal and extreme flight conditions. Six pilots with different experience levels (i.e. novice and experienced) participated in flying the B52 military aircraft from Glasgow in Scotland to Leeds in England under normal and extreme (i.e. severe thunderstorm accompanied by engine failures) conditions using a medium fidelity simulator. The results show that the eye fixation numbers, durations and visual transition characteristics were significantly different between the novice and experienced pilots. In addition, we were able to observe that the experienced pilots increased the visual scanning complexity compared to the novices. The finding might lead to a deeper investigation of how the experts’ visual scanning patterns can be used to train the novices.

Keywords: visual scan, fixation numbers, fixation durations

1. Introduction

Applications of advanced technologies on airplane cockpits have given rise to a surge in procedural requirements and cognitive workload with respect to the pilot’s task (Yu et al., 2016). Interaction between the pilot and the automated system has become more procedural and pilot’s tasks have become more cognitive than ever before (Holden, Ezer, & Vos, 2013). As the aircraft cockpit consists of complex display systems the visual attention become the most important resource of pilots and her/his tasks are characterized by high cognitive workload. Thus, there is a growing need for training effective scanning techniques to improve pilot’s performance (Robinski & Stein, 2013).

The instruments that are used to navigate aircrafts are classified into two categories: control and performance instruments. Control instruments contain tachometers and attitude indicators. The tachometer indicates the engine speed in RPM, while the attitude indicator indicates the attitude of the aircraft in relation to the artificial horizon. Pilots commonly pay more attention to the control instruments to ensure the aircraft is aerodynamically stable (Carnegie, 2008). Accordingly, performance instruments include the remaining instruments on the cockpit display: altimeter, airspeed indicator, climb rate indicator, other instruments (CAA Flight Instructor Guide, 2016). With respect to this study eye tracking area of interest (AOI), as shown in figure 1, can be defined as engines’ indicators, engine oil pressure, attitude indicator, altimeter, airspeed indicator, and enhanced visual screen (see Fig1). Pilots process most of the received information on the cockpit based on the perceived stimulus from the visual scanning (Yu et al., 2016). The eye fixation time reveals the difficulty in extracting information, whereas the number of fixations indicates how important the AOI are (Yu et al., 2016).

The way the pilots visually attend to the actual flight deck is a critical factor in orienting the aircraft and maintaining it stable during the flight mission. There are many studies that have demonstrated the effect of differences of visual scanning pattern on pilot performance. The technology of eye tracking used in this experiment is based on video recordings of the eye movement in real time from a set of cameras located on computer screen. This technology provides eye movement and pupil size information. These measurements are then analyzed using statistical methods to evaluate the differences between two cognitive states (Marshall, 2007).

Eye tracking data are commonly collected and analyzed in terms of fixations over AOIs and rapid movements between these fixations. The number, duration of fixations, and saccadic velocities measurements are typically collected and analyzed using statistical methods. Kasarskis et al., (2001) compared expert and novice scan behaviors during landing using visual flight rules. Eye fixation is defined as steady fixate of the eye on the target for about 100-200 milliseconds. The movement of the eye from one fixation to another is defined as a saccade (Henderson, 1992). The National Transportation Safety Board (NTSB) has identified some causes of human errors: fatigue, sleep, working hour limits, rest requirements, circadian rhythms, visual misperception, experience, and training (Banks et al., 2012).