PILOT VISUAL SCAN PATTERNS DURING LUNAR LANDING MODE TRANSITIONS

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INTRODUCTION

During normal operations, spacecraft and commercial transport aircraft pilots regularly transition between flight control modes. This requires that pilots change their visual scan pattern in order to appropriately adapt. In a previous experiment, we quantified the decrement in pilot flight performance, workload, and situation awareness during expected transitions from automatic to manual flight during simulated lunar landing.[1] However, these measurements only capture the effects of the operators' shifting scan patterns. They do not capture *how* the operators' scan patterns change, which helps to infer how operators have allocated their limited visual attention amongst the display elements. We have conducted a second experiment that measured visual fixations during expected manual-to-auto and auto-to-manual mode transitions in simulated lunar landing.

METHODS

Twelve subjects flew a fixed-based lunar landing simulator through six different mode transitions. Their visual fixation on the display elements was directly measured with a Tobii x50 (Stockholm, SE) eye tracker. Experimental trials began in one of three control modes: 1) two-axis (pitch/roll) attitude rate command with incremental rate-of-descent control (TA+RoD), 2) two-axis attitude rate command with automatic rate-of-descent (TA), or 3) fully automatic (Auto). After twenty seconds, subjects were cued to initiate a pre-defined transition to one of the other two modes. In addition to the subject's eye tracker data, we measured the pilots flight performance (RMSE of actual vs. guidance recommended attitude), objective workload via a two-choice secondary task, and verbal callouts of the vehicle's fuel and altitude state at predetermined intervals, which were used to assess their situation awareness.

RESULTS

The 20 seconds post mode transition were partitioned into five 4-second windows, and the average number of fixations / window was calculated for each mode transition. We found few significant differences in the number of fixations / window between transitions that ended in the same control mode (Figure 1). This suggests that subjects were able to quickly adapt their visual scan pattern to the new mode. Subjects were also found to prioritize the altitude call-outs over the fuel call-outs, indicated by the relative number of fixations / window (Figure 1) and call-out performance (Figure 2). This is believed to be a function of the instruments' locations on the display, as the altitude indicator is located in the center of the display and the fuel indicator is located at the left edge.

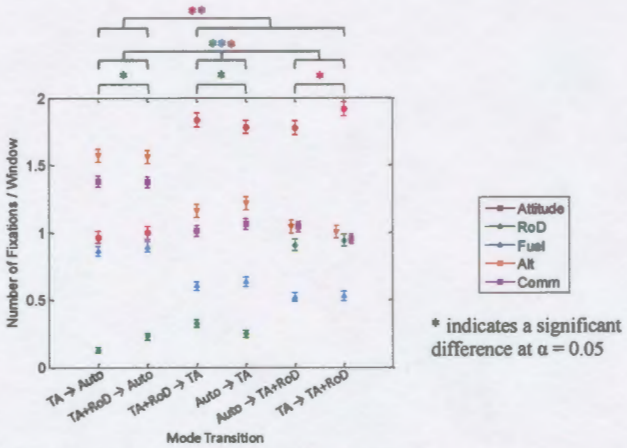

Figure 1. No significant difference was found between mode transitions that end in the same control mode

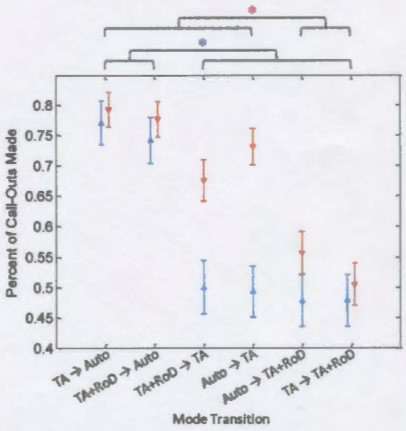

Figure 2. Performance on fuel call-outs drops for mode transitions ending in two-axis control, while performance on altitude call-outs remains high for this mode

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[1] Hainley, C. J., Jr., Duda, K. R., Oman, C. M., & Natapoff, A. (2013). Pilot Performance, Workload, and Situation Awareness During Lunar Landing Mode Transitions. *Journal of Spacecraft and Rockets*, 50, 793-801. 10.2514/1.A32267.