Assessing pilots' mental workload using touchscreen inceptor for future flight deck design

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SUMMARY

Touchscreen displays are one of the pillars of future flight deck design and it is foreseen that at some point traditional flight control inceptors will be modified to a touchscreen version. However, this transition can only be safe and successful with due regard for human performance implications. This study addresses it by comparing pilots' mental workload for a traditional sidestick and an innovative touchscreen control inceptor. The results indicate that the new technology increases pilot workload, suggesting that further development is required to use it in future flight decks.

KEYWORDS

Cockpit design, Human-machine interface, Mental workload

Introduction

Touchscreen displays are already featured in the cockpit of commercial aircraft and the use of this technology is proposed for the next generation of flight decks (Li et al., 2022). Since touchscreens have been proved beneficial for certain applications (Stanton et al., 2013), futuristic cockpit designs explore the possibility of replacing traditional flight controls with touchscreen inceptors. While such a replacement could reduce pilot training time and costs, a new control inceptor must address all requirements for manual flight control and be compliant with human-centered design principles. To understand the characteristics of an innovative flight control inceptor from a human factors perspective, this paper investigates differences in pilots' mental workload when using a traditional sidestick and a touchscreen inceptor in a realistic operational environment.

Methods

The experiments involved 26 participants aging from 21 to 46 years old (M = 28, SD = 7.1) with varying levels of flight experience (M = 257.7, SD = 709.3) and were conducted in the Future Systems Simulator (FSS). The FSS is a reconfigurable simulator, allowing the quick switch between traditional flight controls to an innovative touchscreen inceptor consisting of a touch sensitive region in the Primary Flight Display (PFD) in which a sign can be moved to control the attitude of the aircraft. Each participant executed a landing scenario using both inceptors. Perceived workload was measured using NASA-TLX, which consists of six load dimensions to be rated from 0 to 100 (Hart & Staveland, 1988).

Results and Discussion

Figure 1 shows the mean NASA-TLX scores for both inceptors. Two-tailed paired t-tests for sample means showed a significant effect of the inceptor in perceived mental workload (NASA-TLX total score) – $t(25) = 2.0$, $p < 0.05$, $d = 0.40$ –, more mental demand – $t(25) = 2.6$, $p < 0.005$, $d = 0.50$ – and frustration – $t(25) = 3.31$, $p < 0.05$, $d = 0.65$. The comparisons for all other partial scores were not statistically significant. The results indicate that the innovative technology increases perceived workload, requiring more mental resources and resulting in higher frustration compared to a traditional sidestick. It is hypothesised that these differences are a consequence of the design and location of the new inceptor. Using the touchscreen control makes it more difficult for the controller to capture relevant information to perform the task (e.g., attitude, glideslope indicator), since the PFD is partially blocked by the controller's own hand, creating the need to look at more places and integrate information from different sources (e.g., outside of the window). Moreover, the lack of a neutral position for the control, associated with the absence of control force feedback and physical barriers to indicate control stops, requires the controller to look at the position of her/his own finger to assimilate command inputs. In addition, the pitch axis in the touchscreen case is reversed in relation to traditional controls, generating an extra mental demand. This combination of factors makes the task more complex and stressful to be executed using the touchscreen inceptor, resulting in an overall higher mental workload.

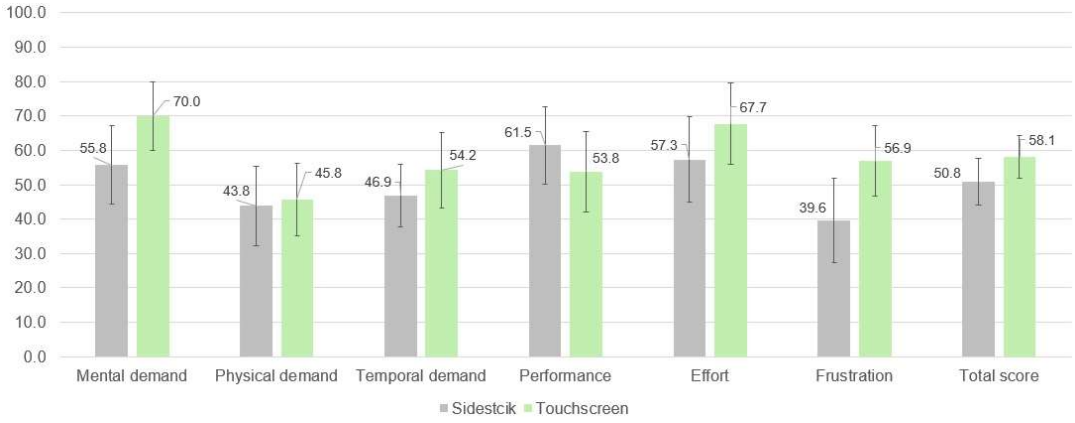

Figure 1: NASA-TLX scores for touchscreen and sidestick

Conclusion

This study suggests that replacing a traditional flight control inceptor with a touch screen increases pilot mental workload, which is linked to the pilots' lack of familiarity with the new design and information seeking. Although touchscreen technology has been proved as beneficial to other applications in the flight deck, it should still be improved as a flight control inceptor to comply with human-centred principles and meet pilot control needs in consideration of the future cockpit design.

References

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