Using Eye Tracking for Improving Tactile Feedback in an Aviation Task

Emanuel Meier
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Supervisors: Prof. Dr. Martin Raubal, Dr. David Rudi, Dr. Peter Kiefer, Luis Lutnyk

IKG
Institut für Kartografie und Geoinformation

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1 Introduction

Pilots must complete a variety of tasks and react to unexpected events while keeping the aircraft in a stable flying mode. Especially rookie pilots can get overwhelmed by the necessity to multitask, lacking the experience to manage priorities correctly [1].

Most information in the cockpit is provided via visual or auditory means. Multiple Resource Theory[2] suggests that using a different modality allows users to process the information more efficiently.

To examine the potential of offloading the audiovisual channels, a belt capable of sending vibration signals[3] was deployed in a flight simulator study. A variety of indicators allowed to measure its impact on the performance, spatial awareness, system usability, and user experience.

2 Study Overview

The study was conducted using a flight simulator provided by Lufthansa Aviation Training (Fig. 1). Participants were verbally instructed to perform flight maneuvers and look for target objects in the environment.

Each of the 22 participants completed one flight with the belt and one without it. If worn, the belt vibrated in the direction of the next target.

Participants wore an eye tracker, allowing the investigator to follow their gaze and determine when they identified objects (Fig. 2). The time to target identification (TTOI), the number of identification attempts, and the number of missed targets were recorded as measures of the participants' performance.

Fig. 1. Participant during the experiment, wearing the tactile belt and eye tracker.

Fig. 2. Eye tracker data showing the scanpaths of participants looking for an object without the belt (left) and while wearing the belt (right).

After each flight, participants drew sketch maps of their flown routes and the object locations to measure their spatial awareness. They also filled in three questionnaires:

- NASA-TLX – measuring cognitive workload
- SUS – measuring system usability
- UEQ – measuring user experience

3 Results and Discussion

The results for the flights conducted with the tactile belt showed the following significant differences:

- Lower TTOI and number of strikes (missed targets) (Tab. 1)
- Lower overall cognitive workload and mental demand (Fig. 3)
- Less effort and better perceived performance (Fig. 3)
- Better system usability and user experience (Fig. 4)

No significant differences were observed in terms of spatial awareness, frustration and physical or temporal demand.

The belt's most named benefit was its directional help, both for completing flight maneuvers and finding target objects.

	No belt	Belt
Wrong ident.	7	2
Strikes	10	0
TTOI	5.84 min	4.54 min

Tab. 1. Performance indicators for both study conditions. Wrong ident. = Participant identified wrong target Strikes = Participant flew past target

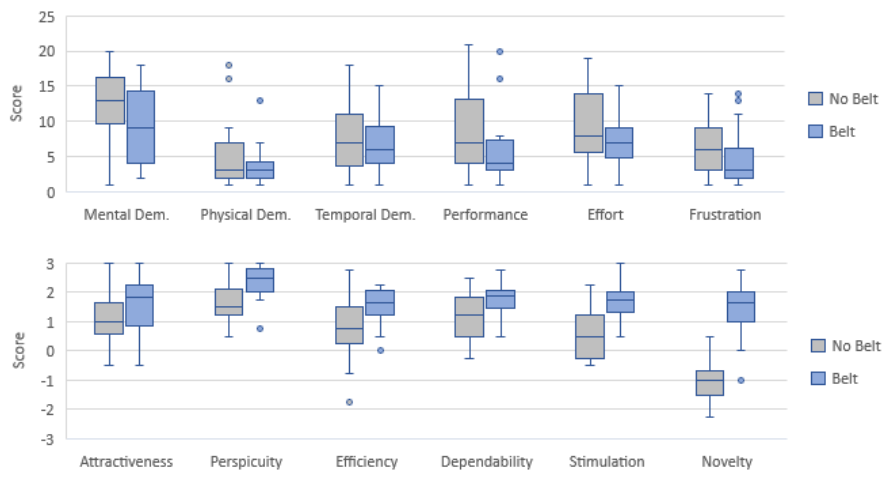

Fig. 3 and 4. NASA-TLX (upper) and UEQ scores (lower) for both study conditions. "Dem." = Demand, points = outliers, bar in box = median.

4 Conclusion and Outlook

This study demonstrated the potential of tactile assistance in general aviation. Multiple significant improvements were observed when pilots were equipped with a tactile belt that guided them towards specific objects. Eye tracking was used to observe participant behavior and progress.

Simplifications and generalizations made the experiment accessible to laymen. Further research should focus on specialized studies with trained pilots and real aircraft, as well as more refined tasks and equipment. This would make the results more representative for real aviation applications.

5 References

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