

Enhancing Pilot Training with Mixed Reality: A Multimodal Study on Effectiveness and Transfer

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Figure 1. MR-Simulator of a PA-28 cockpit at DLR Würselen

Introduction

Primary flight training for **Private Pilot Licenses (PPL)** relies almost completely on real light airplanes.

Disadvantages:

- Dependence on favorable weather conditions
- Limited availability of airplanes, instructors, and air space
- High emissions, maintenance efforts, and costs.

Mixed-Reality (MR) presents a promising approach to developing effective and flexible flight simulators at significantly lower costs: While sitting in a simplified physical flight simulator, pilots are wearing a Virtual-Reality head mounted display (VR-HMD) with video passthrough which enables them to interact with real input devices (Fig. 1 and Fig. 3).

The present study is part of the **ALiTrain** project running at the German Aerospace Center (DLR) in cooperation with two German flight schools.

Focus: The effectiveness of flight training performed in a newly built MR-simulator representing a Piper PA-28. If our results confirm the viability of MR-simulators for a crucial part of light aircraft training, an important step in validating and later on certifying these simulator types is achieved.

Research question: Are basic flight skills acquired in the simulator equivalent to those developed in real-world flight training?

Method

Two groups of flight students are compared in a forward-transfer study: One group attends regular training in a real light airplane (REG group) while the other group is trained in a MR-Simulator (SIM group) after an initial real airplane session (Fig. 2).

Sample (so far)

- 6 active flight students (1 f, 5 m)
- Age 21 – 36 yrs (M = 24.2 yrs, SD = 5.9 yrs)
- Height 175 – 195 cm (M = 182.2 cm, SD = 6.8 cm)
- Practical training experience: 0 to 54 hrs (M = 2.5)
- Theoretical training experience: 100 to 914 hrs (M = 774.5)
- Compensation: 250 €



Figure 2. Study plan

Experimental Setting

Participants of the REG group perform five training sessions with regular traffic pattern. Pre- and post-session questionnaires are filled in by flight students and instructors.

Measures

- Demographic variables
- Training effectiveness:
 - *Flight performance*
 - *Workload (NASA-TLX)*
 - *Situational Awareness (SAS)*
- Potential covariates:
 - *Training-related Motivation (FAM)*
 - *Perceived Stress Reactivity (PSRS), Self-Efficacy (SWE), Personality (BFI-2-S)*



Figure 3. MR environment displayed by HMD with gaze point

Results

- Students' flight performance increased over the course of the sessions in both self- and instructor-ratings (Fig. 4).
- Paralleling this, the flight students' situational awareness improved (Fig. 5) and perceived workload decreased (Fig. 6) substantially after session 3.
- Preliminary analysis of the covariates, namely training-related motivation (FAM) and perceived stress reactivity (PSRS) revealed no extreme values (Fig. 7 and 8).
- General self-efficacy (SWE) indicated an average belief of the students in their ability to successfully manage challenging situations through their own efforts.
- The students' personality profile (BFI-2-S) compared to reference mean values showed slightly higher scores on agreeableness and conscientiousness and lower scores on negative emotionality. Extraversion and open mindedness were average.

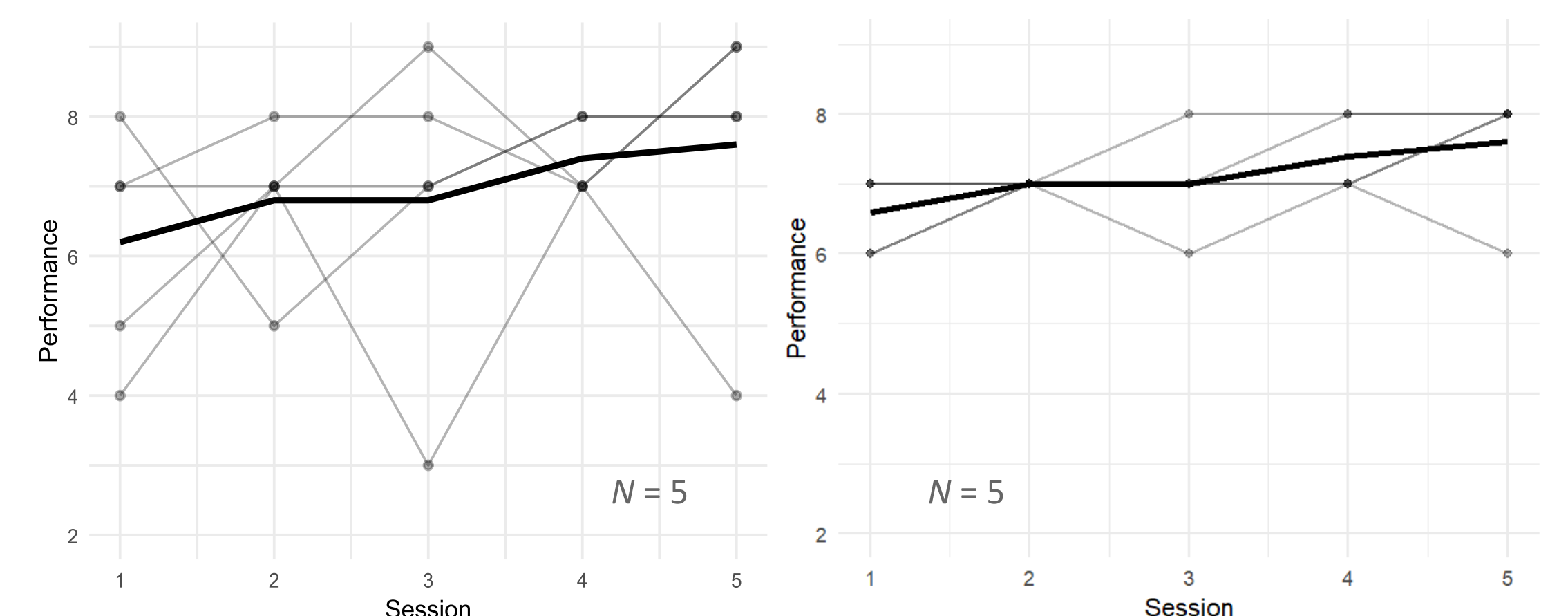


Figure 4. Global flight performance per session rated by student (left) and instructor (right; scale range 1-9)

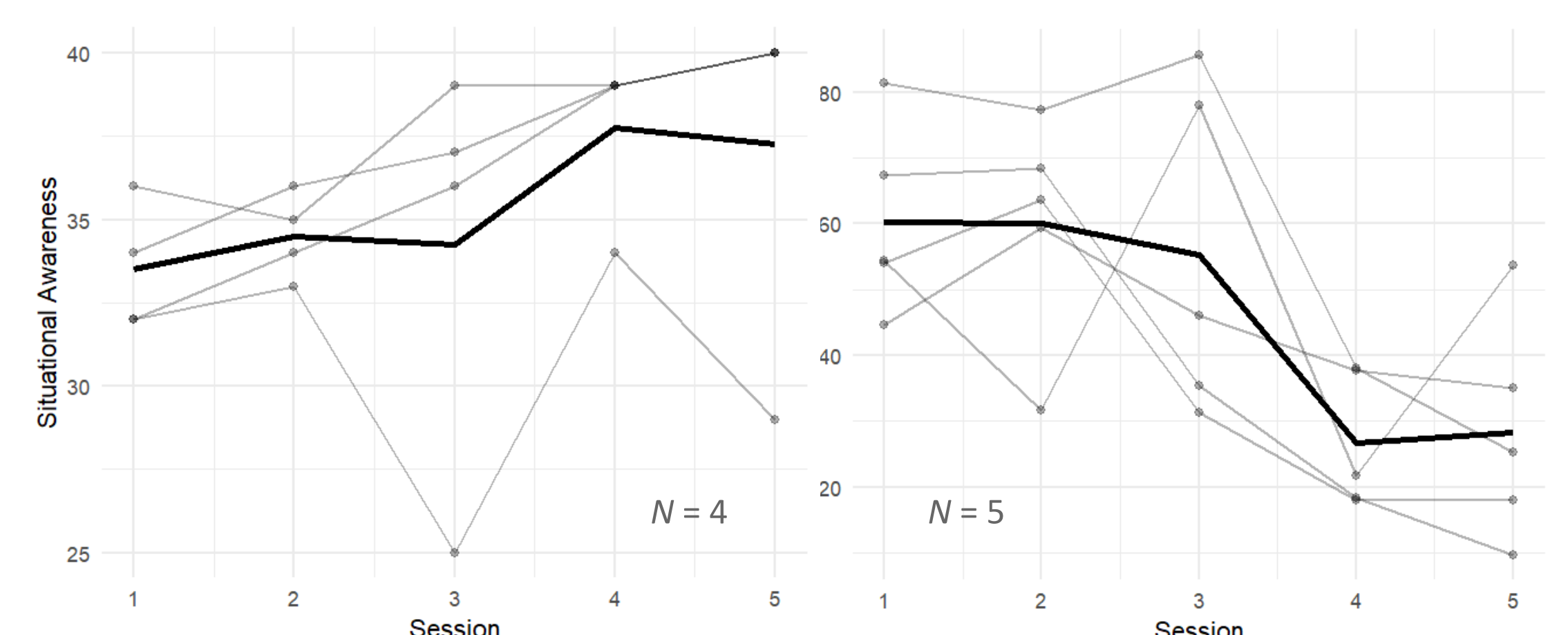


Figure 5. Situational awareness of students (SAS) rated by instructor

Figure 6. Perceived workload by student (NASA-TLX total)

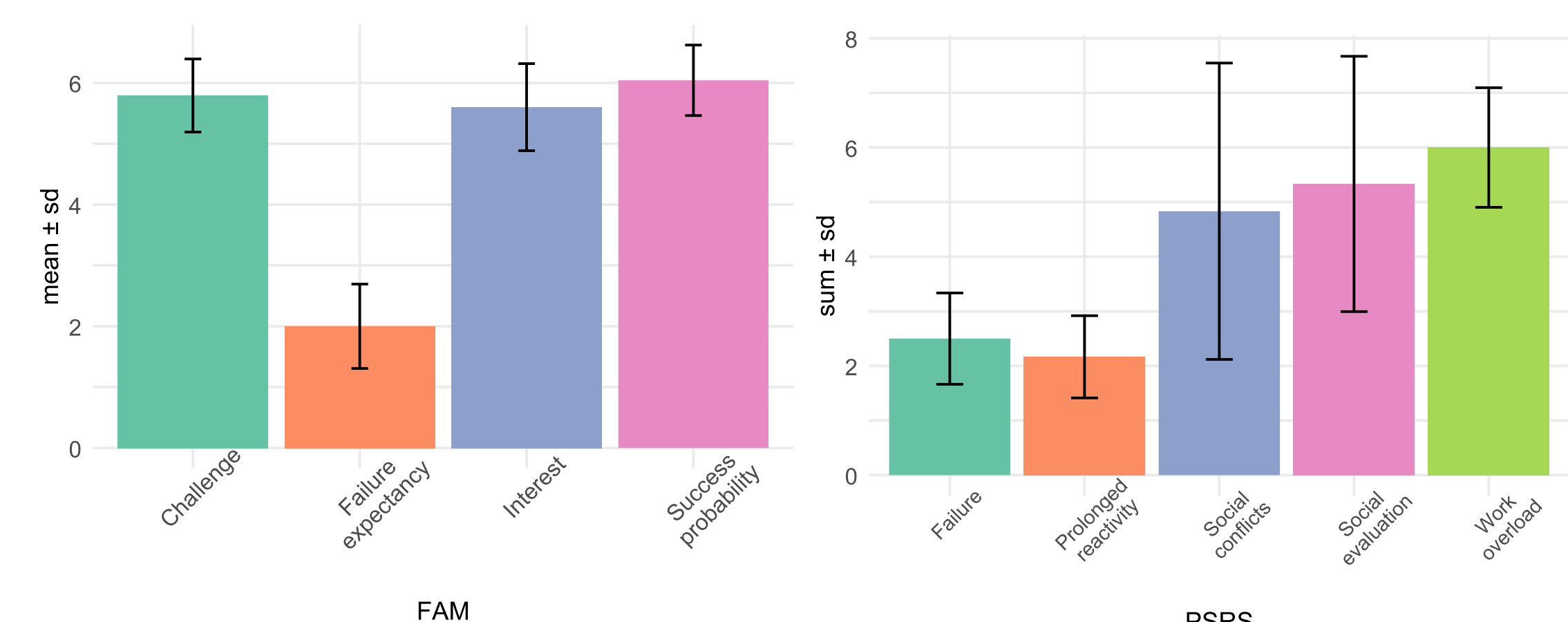


Figure 7. Training-related motivation (FAM)

Figure 8. Perceived Stress Reactivity (PSRS)

Discussion

- As expected, flight students' training performance improved (descriptively) over the five training sessions which can be inferred from all three training effectiveness indicators.
- Large differences in individual progressions were observed, e.g. in training session 3. Post session questionnaires showed that weather conditions created a more difficult flight scenario in the respective sessions. For the SIM group, it is planned to reproduce and match weather conditions to real-life counterparts as closely as possible to balance both groups and to increase comparability between groups.

Overall, our first results can serve as proof of concept. As soon as the simulator is available for data assessment, additional analyses, e.g. regarding group comparisons will be performed. Objective parameters including flight path deviations derived directly from the simulator and eye tracking data like gaze behavior are assessed, serving as additional markers of training progress.