Evaluation of Virtual Reality and Motion for Upset Prevention & Recovery Training (UPRT)

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SUMMARY

The effectiveness of Virtual Reality (VR) and motion in Upset Prevention and Recovery Training (UPRT) for general aviation pilots was investigated. Preliminary findings suggest that VR in combination with motion improved the pilot's ability to recognise and attempt upset recovery in selected upsets and has the potential to enhance aviation safety.

KEYWORDS

Upset prevention and recovery, virtual reality, motion, human factors

Introduction

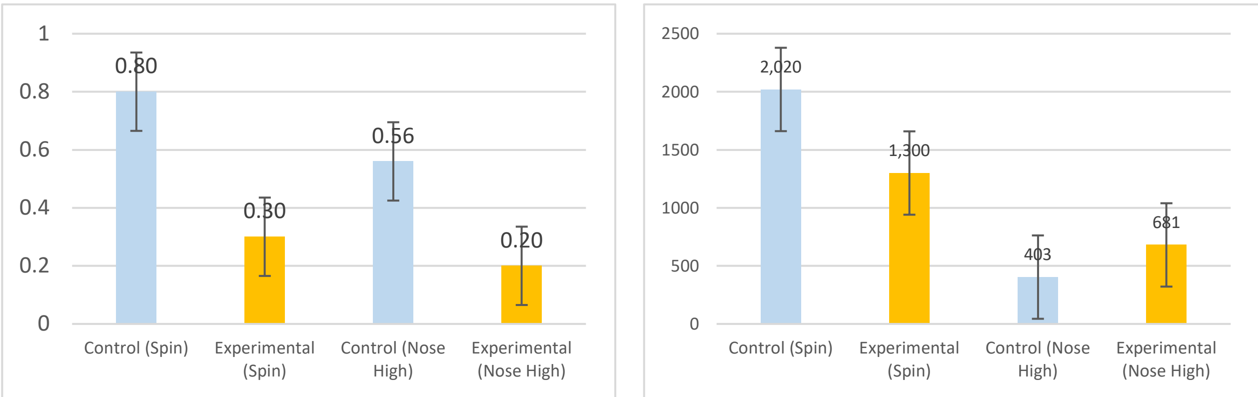
Within EASA member states during the period 2013 to 2022, 719 people lost their lives in light aircraft accidents (EASA, 2024). Loss of control in flight or LOC-I, an 'extreme deviation from intended flightpath' (Bromfield & Landry, 2019) accounted for 22% of these fatal accidents. Causal and contributory factors leading to LOC-I include failure to recognise this type of event and/or delayed recovery of the aircraft to normal flight. Aircraft can lose control in high or low nose attitudes and in extreme cases enter a spin - the most lethal manifestation of LOC-I (Skybrary, 2025). In a spin, an aircraft may rapidly descend at a rate of 28 to 41 m/s (3,326 to 4,871 feet per minute) in a helical path (Kershner, 2006). Current UK regulations for the Private Pilot's Licence (Aeroplane) (CAA, 2025) do not require the pilot to undertake full spin training in a light aircraft due to safety concerns of practicing high-risk manoeuvres in a real-world environment. Today, the majority of general aviation pilots have never experienced a fully developed spin in an aircraft. In contrast, professional pilots in Europe undertake mandatory spin training in a real aircraft to improve their situation awareness and response in the event of an upset or spin as part of Upset Prevention and Recovery Training (UPRT) (EASA, 2020). For a general aviation pilot, if loss of control in flight leading to a fully developed spin occurs, it is highly likely that the pilot is experiencing it for the first time. This may result in 'startle' and/or 'surprise' effects (EASA, 2015), pilot inaction or delayed application of the correct recovery procedure with the aircraft rapidly losing height. Technological advancement in simulation and has led to affordable, immersive virtual reality (VR) visual systems and motion systems. A previous study exploring the benefits of ground-based UPRT for general aviation pilots suggested that classroom-based training alone was of benefit (Roger & Boquet, 2012) however this study utilised conventional desktop computers with limited visual presentation. Florek (Florek 2023) investigated the use of VR for UPRT but focussed only on the subjective assessment of the effectiveness of VR. This preliminary research evaluates the effectiveness of VR combined with motion for UPRT using subjective measures of confidence and objective measures of recognition, response and recovery performance.

Method

Ten participants were recruited (8 male and 2 female) with a mean age of 20.9 yrs (SD = 1.91), all were student pilots. Participants had a mean total flight time of 26.6 hrs (SD = 17.15) with mean command time of 3.6 hrs (SD 4.47). Participants were divided into two groups: a control group (n=5) and an experimental Group (n=5) for the between-groups experimental study. Each group received the same aircraft pre-flight briefing including emergency procedures, simulator familiarisation and 10-minute practice flight. The experimental group experienced two pre-recorded upset scenarios in a VR environment with motion, a nose high/airspeed low upset and a fully developed spin. The control group received no exposure to the pre-recorded upset scenarios. Each group was then exposed to the same upset scenarios in pseudo-randomised sequence and were required to effect appropriate recovery. Pilot performance was assessed for recognition of the upset type, the recovery reaction time, adherence to procedure and physiological response (heart rate standard deviation normal to normal or SDNN).

Preliminary Results

Pre-experiment, the control group exhibited slightly more UPRT knowledge than the experimental group (small sample size). Post-experimental results analysis (Figure.1) showed that the experimental group achieved faster reaction times during a spin upset (0.5s, 62.5%) and less altitude loss (850ft, 40%) compared to the control group. The experimental group demonstrated better spin upset recognition (80%) compared to the control group (40%). Confidence levels for spin recovery were also greater for the experimental group (92%) compared to the control group (60%).



(a) Reaction Time (s) **(b) Altitude Lost (ft)**

Figure 1. Experimental Results

Discussion

Preliminary results indicate that the use of VR plus motion produced similar results for simple nose high upset scenario however improved recognition and confidence in complex upsets. It is likely that all participants had experienced nose high upsets during their pilot training in relation to stalls (Exercise 10a in the PPL Syllabus (CAA, 2025)). However, none observed full spin recovery as these are not mandated in the PPL Syllabus The exposure of the experimental group to fully developed spins (complex upsets) using VR and motion is likely to have resulted in faster reaction times and reduced altitude loss.

Conclusions

Preliminary findings suggest that VR in combination with limited motion has potential to enhance general aviation safety by improving a pilot's ability to recognise in the first instance and apply the appropriate upset recovery methods in selected upsets with increased confidence. These findings may be applicable to other transport domains where VR is used in combination with limited motion cues. The number of participants should be increased and in-depth statistical analysis of results completed.

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