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The Effects of Verbal Reports and Spatial Disorientation on Attention: An Eye-Tracking Study

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SUMMATIVE STATEMENT
Through analyzing the pilots' eye movement behavior, this study proved that the execution of Verbal Reports (VR) during flight operations under spatial disorientation (SD) has a positive influence on pilots' attentional functions. Thus, the VR procedure can be recommended as a means to improve attention and to overcome SD effects.

KEYWORDS: Verbal Reports, Spatial Disorientation, Eye Tracking

PROBLEM STATEMENT
SD or the inability to correctly interpret aircraft attitude, altitude and airspeed can adversely affect a pilot's attentional functions, which can then lead to serious aviation accidents. To overcome this predicament, VR, a procedure that requires pilots to verbalize instrumental information during SD situations, are being carried out in the R.O.K. Air Force. However, the impact of VR execution on attention allocation under SD situations remains to be unexplored. Thus, further investigation is essential in order to determine how attention allocation differs when performing VR across different SD situations and to validate the VR protocol's effectiveness in improving pilots' attention.

RESEARCH OBJECTIVE/QUESTION
The purpose of this study is to systematically and objectively analyze the effect of VR execution on pilot's attention across different SD conditions by utilizing eye-tracking measures with convincing examples and scenarios.

METHODOLOGY
The experiment was conducted on 25 male Air Force fighter pilots (age: 30.5 ± 3.8 years; flight time: 752.4 ± 437.5), which is divided into two groups: VR group (14 pilots) and non-VR group (11 pilots). This study evaluated the pilot's attention allocation using a flight simulator and eye-tracking device. GL-4000 (ETC Aircrew Training Systems, USA) was used to simulate the flight environment, and Tobii Pro Glasses 2 (Tobii Technology, Sweden) was used to collect and analyze the pilot's eye movement data. In order to quantitatively analyze the pilot's eye movement characteristics, three Areas of Interest (AOIs) were set: attitude, airspeed, and altitude, which is displayed on the head-up display. In this study, VR execution and six SD types (somatogravic illusion, coriolis, leans, and graveyard spin, false horizon, black hole illusion) were selected as independent variables. In addition, three eye-tracking features (number of fixations, average fixation duration, time to first fixation) for each AOI and a 7-point scale attentional load score were selected as dependent variables. The pilots performed the flight task for 15 minutes under each SD scenarios in the flight profiles. Two-way mixed ANOVA was conducted at significance level 0.05 to identify the effects of VR execution and SD types on attention allocation levels.

RESULTS
Findings showed that the number of fixations and average duration of fixations were significantly higher in altitude and attitude AOIs for the VR execution group than the non- VR execution group. In addition, the VR execution group had significantly lower time to first fixation in the attitude AOI than the non-VR execution group. On the other hand, in terms of

SD types, coriolis yielded significantly higher number of fixations in airspeed, altitude, and attitude AOIs than graveyard spin, leans, and black hole illusion, respectively. Moreover, coriolis had significantly higher attentional load score than graveyard spin, leans, false horizon, and somatogravic illusion. Graveyard spin had a significantly higher average fixation duration in attitude AOI than black hole illusion, while time-to-first fixation was significantly lower. Lastly, interaction effects between VR execution and SD types were not found.

DISCUSSION

It was shown that VR execution helps improve the pilot's attention allocation under SD situations. When performing VR, pilots tend to quickly attend to each instrument more accurately and at the same time perform efficient crosscheck between multiple instruments. On the other hand, it was found that the pilot's attention distribution level tends to differ depending on the critical information needed for each SD type at each flight phase. For example, since coriolis occurred during a flight phase in which the pilot turns while maintaining airspeed and altitude specifications, pilots tend to perform a continuous crosscheck of altitude, airspeed, and attitude information. Thus, this leads to an increase in the required efforts to efficiently distribute one's attention. Additionally, in graveyard spin SD type, since the pilots feel spiral turning, checking attitude information is relatively important. As a result, during this phase, the pilots are more likely to try to shift their attention towards the attitude AOI to understand it as soon as possible. However, despite such efforts, it seems that pilots have some difficulty in interpreting the attitude information as evidenced by their long fixation durations. To extend the findings of the current study, considering other conditions such as gender, age and the actual flight situation is recommended. Through this study, insights with regards to establishing efficient strategies in overcoming SD such as VR execution are presented.

CONCLUSIONS

This study systematically investigated the pilot's attention allocation by VR execution and SD types. The results of this study can be used as an objective basis to prove that the pilot can improve one's attention allocation and to overcome SD situations through VR execution.

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