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Improving spatial awareness in the aircraft cockpit: partially supporting evidence for the concept of scene-linking

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Abstract Flying an aircraft is an often targeted domain for the study of skilled human performance in general and for applied problems of spatial cognition in particular. The flight-deck crew's spatial awareness is mainly informed by the outside view and the primary flight instruments (PFI) with the latter becoming the sole source of spatial information in low-visibility weather conditions. The transparent and collimated head-up display (HUD) and the 3-D perspective pathway-in-the-sky representation format are two wellstudied innovative display concepts with proven evidence of promoting improved spatial awareness of pilots. However, there is also evidence that both display concepts are associated with a sub-optimal distribution of the pilot's visual attention resources between PFI and outside view. In case of the HUD, a delayed or even missing detection of unanticipated events in the outside view has been found. This deficiency has been attributed to attention fixation to the HUD triggered by the presence of differential motion between the static near domain PFI and the dynamic far domain outside world. A pathway-induced attention fixation to head-down views, likewise occurring at the expense of event detection in the outside, has been attributed to the very compelling character of the pathway attracting an undue amount of the pilot's attention resources. These findings raise the question whether a combined pathway-HUD amplifies attention fixation problems with the effect of potentially offsetting the independent and conclusively established benefits of both display concepts. The aim of the present study was to test the hypothesis that HUD symbology that is presented scene-linked, thus moves as virtual instrument gauges in the outside scene can promote a better distribution of attention between both visual domains. Such an advantage has been substantiated in simulated aircraft operation on the airport surface where a pathway of runway route markers was overlaid to the existing runway edges. We developed a part-task simulation to investigate an airborne application of this concept using the pathway-in-the-sky as an outside-world referent for the projection of virtual PFI in the world. Experienced pilots (N = 14) flew a series of low-altitude curved trajectories through mountainous terrain and had to detect display events (discrete changes in a command speed indicator to be matched with current speed) and outside scene events (hostile SAM stations on ground). The speed indicator was either superimposed with a fixed HUD-location or attached to the pathway, thus underwent the same visual transformation as the object elements of the pathway during the dynamics of the flight. Outside scene event detection was superior using PFI with a scene-linked HUD location as compared to a fixed-HUD location, however, flight-path tracking was markedly deteriorated. Reasons for and means to cope with this performance trade-off will be discussed.

Keywords Spatial awareness · Aircraft cockpit · Head-up display · Pathway-in-the-sky · Attention fixation · Scene-linking

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