Visual Information Processing From Multiple Displays

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Objective: In this study, we examined how effectively people can monitor new stimuli on a peripheral display while carrying out judgments on an adjacent central display.

Background: Improved situation awareness is critical for improved operator performance in aviation and many other domains. Given the limited extent of foveal processing, acquiring additional information from peripheral vision offers high potential gains.

Method: Participants carried out a sequence of central perceptual judgments while simultaneously monitoring the periphery for new stimuli. Peripheral detection was measured as a function of central-judgment difficulty, the relative timing of the two tasks, and peripheral event rate.

Results: Participants accurately detected and located peripheral targets, even at the highest eccentricity explored here (~30°). Peripheral detection was not reduced by increased central-task difficulty but was reduced when peripheral targets arrived later in the processing of central stimuli and when peripheral events were relatively rare.

Conclusion: Under favorable conditions—high-contrast stimuli and high event rate—people can successfully monitor peripheral displays for new events while carrying out an unrelated continuous task on an adjacent display.

Application: In many fields, such as aviation, existing displays were designed with low-contrast stimuli that provide little opportunity for peripheral vision. With appropriate redesign, operators might successfully monitor multiple displays over a large visual field. Designers need to be aware of nonvisual factors, such as low event rate and relative event timing, that can lead to failures to detect peripheral stimuli.

Keywords: peripheral detection, aviation, attention, dual task, situation awareness, monitoring, vigilance

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INTRODUCTION

Advances in technology are rapidly increasing both the amount of data available in domains such as aviation and the technical capability to display huge amounts of data to human operators. In contrast, the cognitive architecture of the human operators is essentially fixed, and its information-processing capability is severely limited. The developing mismatch looms as an important problem. How can we arrange for human operators to monitor the vast amount of displayable data without being overwhelmed?

In aviation, situation awareness has been identified as a key to improving pilot performance (Endsley, 2000; Woods & Sarter, 2010). In the past, cockpit situation awareness has mainly been accomplished by sequential scanning of displays designed to be processed in central vision. Major augmentations in cockpit displays are already being tested. The Primary Flight Display is morphing into a Synthetic Vision System (Prinzel, Kramer, Arthur, Bailey, & Comstock, 2005), which will fuse information from multiple sensors and possibly include add-ons for desired path, terrain, weather, and so on. Navigation displays are morphing into Cockpit Situation Displays (Granada, Dao, Wong, Johnson, & Battiste, 2005), which augment standard traffic display with projected paths, 3-D rotation capability, plus added information about terrain and weather.

The challenge to cockpit design is to enhance pilots' ability to acquire what they need from the wealth of information displayed. In part, this requires tailoring each display to facilitate acquisition of needed information. But an additional objective should be to allow pilots processing one display in central vision to simultaneously acquire important additional information from other peripheral displays. The present research tests the extent to which this is possible, examining the case of detection of salient peripheral events. Such events could represent, for instance,