Driven to Distraction: Why do Head-Up Displays (HUDs) Impair Driving Performance?

Jobina Li (jliq@connect.carleton.ca)
Institute of Cognitive Science, Carleton University
1125 Colonel By Drive, Ottawa, Ontario, K1S 5B6

Keywords: Attention; Head-Up Displays (HUDs); Human Factors

Introduction

Traditionally, research on avionic HUDs has attributed the costs of HUDs to "cognitive capture", referring to the tendency of HUDs to monopolize visual attention and thereby interfere with pilots' navigation ability (Weintraub, 1987). However, the label "cognitive capture" confounds lower-order (stimulus-driven) visual attention processes with higher-order (goal-driven) semantic processes. Thus, the present study manipulated HUD information (irrelevant: random letters vs. relevant: speed information) and HUD location (central vs. peripheral) in a simulated driving task to investigate the stage(s) at which a digital speed HUD might interfere with driving performance. The manipulations in this study were designed to determine whether the impairments in driving performance associated with HUDs were primarily due to stimulus-driven attentional capture by the abrupt onsets of HUD symbology (Yantis & Jonides, 1984) or to goal-driven semantic processing of HUD symbology (Brown & Craik, 2000). HUD location was manipulated to investigate if central or peripheral locations either enhanced or diminished potential HUD information effects.

Hypotheses

1. If higher-order semantic processing of HUD information is required to extract meaning, then performance decrements should only be observed in the HUD-relevant condition, given that fewer cognitive resources are available to devote to HUD processing. Greater driving decrements should also be observed when the HUD is centrally located than when it is located in the periphery.
2. The alternative hypothesis is that the constantly changing HUD symbology operates as a series of abrupt onsets that continually capture visual attention, to the extent that drivers are unable to sufficiently attend to the task of driving. As such, performance should be statistically identical across HUD information conditions. Greater driving decrements should be observed when the HUD is centrally located than when located in the periphery.

Method

The sample consisted of 20 Carleton University undergraduates, aged 18 years of age and over who in possession of a valid driver's licence and had at least one year of prior driving experience.

The study was a 2 (HUD Location: central, peripheral) x 2 (HUD Information: relevant, irrelevant) repeated-measures design in which participants were instructed to obey all conventional road rules in a simulated driving environment while simultaneously responding to a visual probe (in the form of a perceptual detection task: PDT) by making a button press. Driving performance was assessed in terms of speed monitoring, lane position monitoring, PDT hit rates and PDT reaction times.

Results/Discussion

There were no significant main effects of HUD Information on speed monitoring, lane position monitoring, PDT hit rates or PDT reaction times. Driving performance was statistically identical for both HUD-relevant and HUD-irrelevant conditions. These data were inconsistent with the view that higher-order semantic processing of HUD symbology alone impaired driving performance. Instead, this pattern of results was consistent with the claim that abrupt onsets associated with HUD symbology were responsible for decrements in driving performance, via their continual and inexorable capture of visual attention.

In terms of HUD Location, no significant main effects of speed monitoring, lane position monitoring PDT hit rates or PDT reaction times were observed. Contrary to predictions, a peripherally presented HUD appeared to be as salient a source of distraction as a central HUD presented at fovea.

Acknowledgments

This work was supported by members of Carleton University's Aviation and Cognitive Engineering Lab. Special thanks go to Dr. C. Herdman, Dr. M. Brown, Jon Wade and Dan Bleichman.

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