

The Effects of Augmented Reality Head-Up Display Graphics on Driver Situation Awareness and Takeover Performance in Driving Automation Systems

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Introduction

- Various technologies exist utilizing SAE Level 3 automation.
- Currently, TORs utilize head-down displays (HDDs)
- Future human-machine interfaces may employ the use of an augmented reality (AR) head-up display (HUD)
- Typically, HUDs utilize two visualization strategies, screen-relative and world-relative graphics.
 - Screen-relative graphics deliver visual information to drivers while being attached to the HUD on the windshield.
 - World-relative graphics deliver visual information spatially attached to the world itself



Objective and Method

This study sought to investigate the effects of AR HUDs and Head Down Display (HDD) graphics on driver situation awareness (SA) and takeover performance.

User Study:

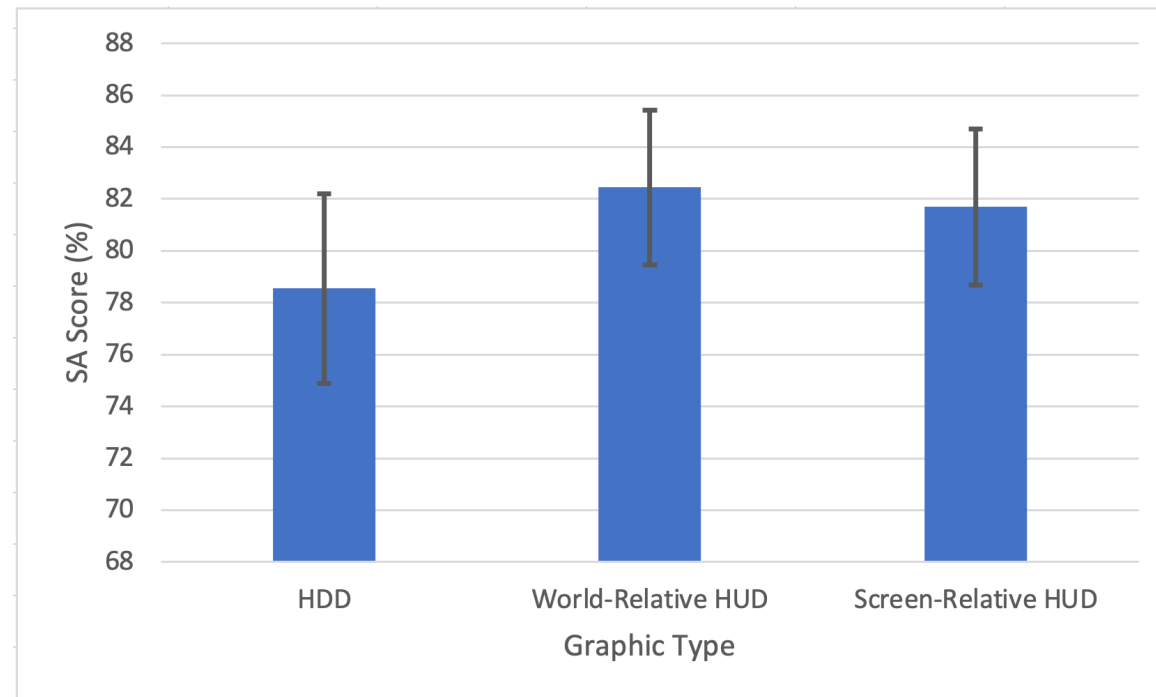
- 21 participants
- Each participant experienced a TOR from three visual graphic types, world-relative HUD, screen-relative HUD, and HDD.
- We measured driver SA and takeover performance



Results

Situation Awareness:

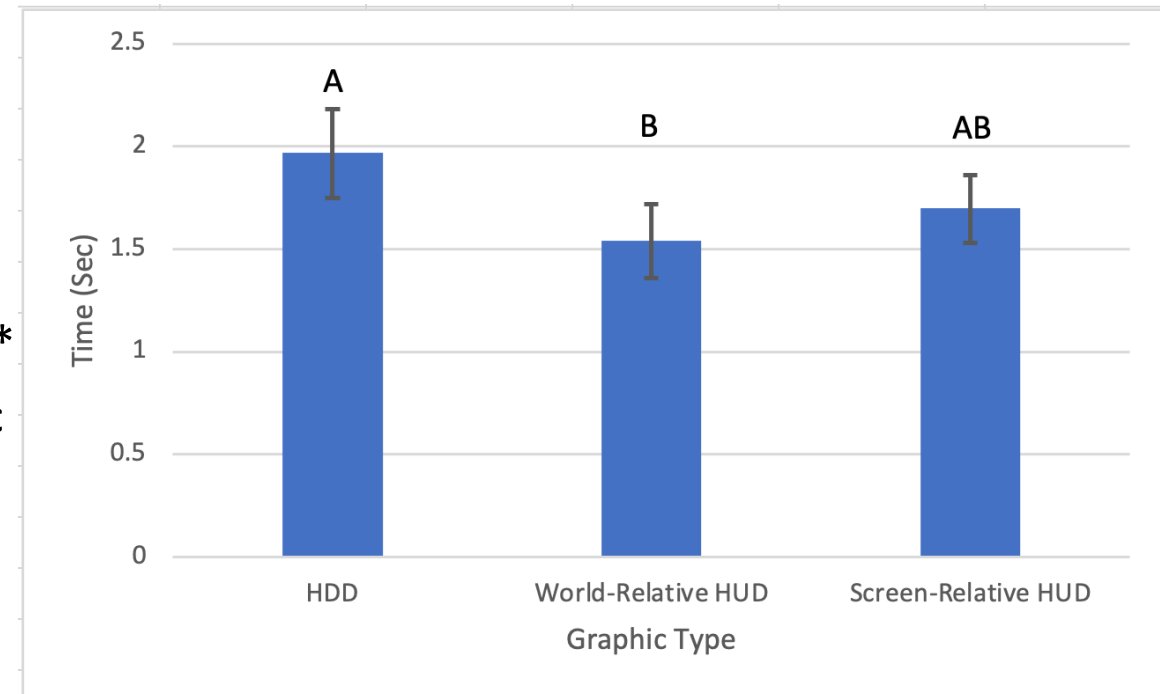
- Overall SA Mean scores:
 - HDD graphic condition: 78.55%
 - World-relative HUD graphic condition: 82.45%
 - Screen-relative HUD graphic condition: 81.69%



Results

Initial Response Time (IRT)

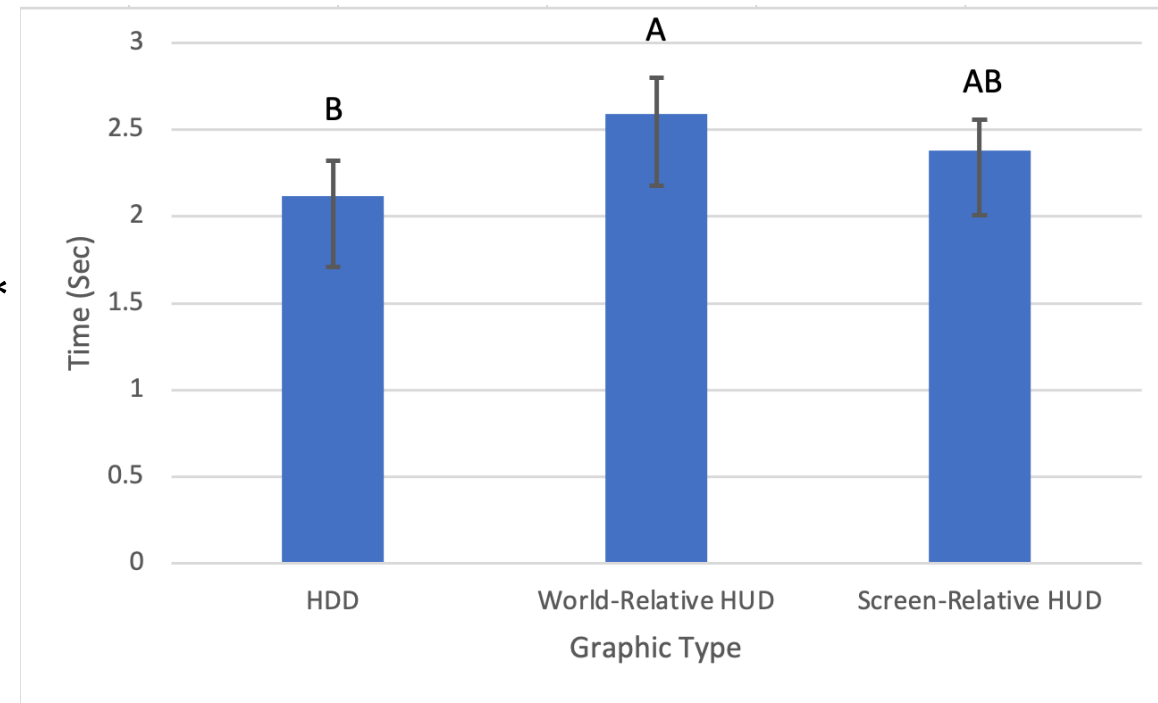
- Average ITRs:
 - HDD graphic condition: 1.97 sec*
 - World-relative HUD graphic condition: 1.54 sec*
 - Screen-relative HUD graphic condition: 1.70 sec



Results

Time to Collision (TTC)

- Mean TTC scores:
 - World-relative HUD graphic condition: 2.71 sec*
 - Screen-relative HUD graphic condition: 2.34 sec
 - HDD graphic condition: 2.11 sec*



Results

Correct action

- 9 times as likely: World-relative graphic condition than the HDD graphic condition.
- 3.5 times as likely: Screen-relative graphic condition than the HDD graphic condition



Conclusion and Application

- Results did not directly support the use of AR HUDs to increase driver SA during takeover in vehicles equipped with driving automation systems
- Participants showed increased takeover performance regarding initial response time, time to collision, and reaction accuracy
- Results of this study found that HUDs support increased driver performance which may help inform future designs of TORs for Level 3 driving automation systems



References

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