

Evaluation of Visual Alerts on a Head-Up Display Considering Driving Experience

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(a) A: Route-overlay instruction (b) B: Hazard prediction alert (c) C: Meter-based driving advice (d) D: No alert
Fig. 1 Visual alert presentation conditions used in the sensory evaluation experiment

Insufficient safety checking is a major contributing factor in traffic accidents, motivating research on in-vehicle interfaces designed to support safer driving. However, false or unnecessary alerts may undermine drivers' trust in such systems. This concern is particularly relevant in situations involving latent hazards, such as uncontrolled intersections with limited visibility. Although visual alerts may reduce uncertainty, they may also be perceived as unnecessary or intrusive when no immediate hazard is evident. Moreover, drivers' responses to such alerts may vary according to their individual characteristics. This study investigated how driving experience influences the effects of visual alerts on subjective evaluations and driving behavior at uncontrolled intersections with limited visibility.

A driving simulator experiment was conducted with 30 participants, comprising 15 less-experienced drivers with fewer than five years of driving experience and 15 more-experienced drivers with five or more years of driving experience. A mixed experimental design was used, with the alert presentation condition as the within-subjects factor and the driving experience group as the between-subjects factor. Figure 1 illustrates the four visual alert conditions. Condition A, the route-overlay instruction, superimposed road markings and a deceleration instruction onto the vehicle's projected path. Condition B, the hazard-prediction alert, indicated the possible presence of an approaching vehicle on the intersecting road. Condition C, the meter-based driving advice, displayed a safe-driving evaluation and deceleration advice on the instrument panel. Condition D, the no-alert condition, served as the baseline. Alerts in Conditions A–C were presented five seconds before the vehicle reached the target intersection.

After a practice session, each participant drove an approximately 3-km route under each condition and passed through five uncontrolled intersections with limited visibility. A queue of stationary vehicles in the opposing lane obstructed the driver's view of the intersecting road, but no vehicle approached from the side road. After each condition, participants rated their perceived safety, perceived intrusiveness, perceived coerciveness, and other subjective impressions. Driving behavior and gaze behavior were recorded throughout the experiment. Participants also completed questionnaires and took part in interviews.

Data from 29 participants were analyzed after one participant in the less-experienced group was excluded. A mixed-design two-way analysis of variance on the aligned-rank-transformed perceived-safety ratings revealed significant main effects of alert presentation condition and driving experience group, as well as a significant interaction between these factors. Less-experienced drivers reported higher perceived safety under Conditions A and C, suggesting that direct guidance was perceived as supportive. By contrast, more-experienced drivers appeared to perceive such guidance as intrusive. The group difference was smaller under Condition B, which provided hazard information without prescribing a specific driving action.

For deceleration magnitude, only the main effect of alert presentation condition was significant. Post hoc multiple comparisons revealed significantly greater deceleration under Condition A than under Conditions B, C, and D, and significantly greater deceleration under Conditions B and C than under Condition D.

These findings indicate that visual alerts promote deceleration regardless of driving experience, whereas their effects on perceived safety vary with driver experience. This suggests the importance of considering driver characteristics when designing visual alerts to promote safe driving behavior while maintaining driver acceptance.