Research
Report Summary

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A Driving Simulator Investigation of Road Safety Risk Mitigation under Reduced Visibility

The effect of low visibility on both crash occurrence and severity is a major concern in the traffic safety field. It is known that crashes tend to be more severe in low-visibility conditions than under normal clear conditions. For instance, a severe fog crash with 70-vehicle pileup happened on I-4 in Polk County, FL, in January 2008. This crash caused five deaths and many injuries (Hassan and Abdel-Aty, 2011).

In order to improve driver safety under fog conditions, the research team investigated drivers' behavior issues relevant to implementing a visibility system on Florida's highways under reduced-visibility conditions.

It is necessary to detect any reduction in visibility and develop efficient ways to convey warnings to help drivers prepare for dangerous situations. For this reason, we designed driving simulator experiments to evaluate how drivers respond to low-visibility warning strategies using an in-vehicle device. Meanwhile, previous studies showed that drivers may adjust their behaviors under fog conditions.

Figure 1: Heavy fog condition in driving simulator

Figure 2: Head-up display warning

It was found that drivers are prone to decrease their speeds under fog conditions, but that the reduction was insufficient, especially when dangerous situations occurred. Based on the above point, the effects of different fog levels were investigated in this study.

Two different fog levels were considered in this research: dense fog (300 ft.) and moderate fog (100 ft.). In addition, three types of warning strategy (head-up display (HUD) & audio, HUD only, no warning) were included in the experiment. In all, six scenarios were designed and 48 participants were recruited for the driving simulator experiment.

In the experiments, the lead vehicle had an emergency brake under fog conditions. During the emergency event, drivers' crash-avoidance behaviors can be observed. These behaviors can be divided into two parts: the throttle-release process and the braking process. It was found that drivers' throttle-release reactions were faster with the provision of warning strategies. Meanwhile, drivers' braking processes were smoother when the warning systems were present. No significant effects were observed by gender and different fog levels.

Four indicators were employed in order to evaluate traffic safety: perception response time (PRT), minimum time-to-collision (TTC), response time, and brake peak value. The results showed that driver safety is related to both fog levels and warning systems, while significant impacts of gender were observed under dense fog conditions only. The results indicated that older drivers were prone to brake harder in the emergency situation. The questionnaire evaluation results showed that provision of warning information through HUD had better effects than warning sounds.

Meanwhile, the results showed that drivers who drove less than 5 times every week or had higher educational attainment rates (a bachelor's degree or higher) were more likely to have larger minimum TTC.

Considering the results of drivers' crash-avoidance behavior under low-visibility conditions, we can conclude that a warning system could improve driver safety in emergency situations. It was also found that traffic safety under low-visibility condition is related to visibility levels, driver age, travel frequency, and education levels. Moreover, different fog warning systems, such as the Fog Detect & Warning System (Lee et al., 2012) and the Intelligent Guidance System (Li et al., 2011), could be considered in a follow-up study.

References

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