

Effects of Cataract-Related Lens Opacity on Driving Behavior in Low-Light Conditions

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KEY WORDS: Human engineering, Elderly person, Driver behavior, Cataract, Lens opacity (C2)

Purpose

Cataract is a common age-related eye disease that degrades visual function under low-light and glare conditions. This study aimed to clarify the effects of cataract-related lens opacity on driving behavior during dusk and nighttime driving. Furthermore, the study aims to identify indicators of cataract-related changes in everyday driving behavior and contribute to the continued safe driving of older adults.

Experimental Method

A high-brightness, high-resolution driving simulator with a 210-degree field of view was used to reproduce low-light and glare environments. Two driving scenarios were developed: a dusk-driving scenario and a nighttime-driving scenario.

In the dusk-driving scenario, right-turn behavior was compared between daytime and dusk conditions. The scenario included motorcycle, pedestrian, and bicycle events. Gaze and hazard-avoidance behavior were measured. In addition, the time required to recognize destination-sign text was recorded.

In the nighttime-driving scenario, the effects of glare from oncoming vehicle headlights were evaluated (Fig.1). Driving behavior was compared between daytime and nighttime conditions, as well as between situations with and without oncoming vehicles.

Participants were 20 older drivers aged 68-82 years and 16 employees aged 45-60 years. Among the older drivers, 10 had undergone cataract surgery and 10 had no history of cataract surgery. Visual acuity and lens opacity were measured using an autorefractometer. Participants with opacity in the central region of the crystalline lens were classified as the Cataract Group, while those without opacity were classified as the Non-Cataract Group.

Results

In the dusk-driving scenario, the Cataract Group tended to reduce their turning speed during right turns compared with daytime driving. In contrast, no significant group differences were observed in the detection times for motorcycles, pedestrians, or bicycles. These findings suggest that compensatory behavior, such as reducing speed, may have contributed to hazard avoidance under low-light conditions. However, the Cataract Group required longer times to recognize destination-sign text, and this tendency was particularly pronounced under dusk conditions. This result implies that reading destination signs while driving may increase the risk of forward inattention among drivers with cataract-related visual impairment.

In the nighttime-driving scenario, the Cataract Group also tended to drive more slowly when passing oncoming vehicles, indicating compensatory behavior under glare conditions. However, in a pedestrian dart-out event beyond a nighttime curve, only 50% of the Cataract Group successfully avoided the pedestrian, whereas 80% of the Non-Cataract Group did so (Fig.2). These findings indicate that, even when compensatory behavior is adopted, the detection and avoidance of hazards may be delayed under extremely low-contrast conditions.

Conclusion

The results suggest that drivers with early cataract may compensate for reduced visibility in low-light and glare environments by reducing vehicle speed. However, they require more time to recognize destination signs and may exhibit delayed hazard avoidance when encountering difficult-to-see objects. These findings highlight the potential need for destination-sign recognition assistance and hazard-avoidance support systems. Furthermore, the results suggest that cataract-related signs may be identifiable from driving behavior under varying illumination and glare conditions. Future work will investigate the level of visual-function decline at which driving assistance becomes necessary.



Fig.1 Nighttime Driving Scenario

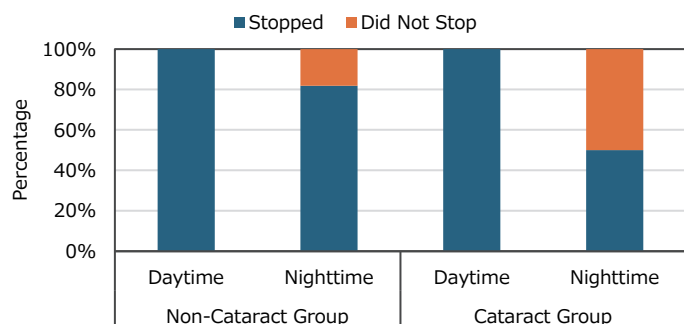


Fig.2 Percentage of drivers who stopped for pedestrians