

# Detection of Reduced Attention Using the Eye-Centering Phenomenon in a Driving Simulation Environment

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Driver's inattention caused by cognitive distraction is recognized as a major contributor to traffic accidents and remains a critical challenge for driver monitoring systems. Previous studies have reported an eye-centering phenomenon, in which gaze behavior becomes concentrated around the center of the visual field when attentional resources available for driving decrease. However, evidence for this phenomenon has primarily been obtained under simplified laboratory conditions involving visual target-tracking tasks. Consequently, it remains unclear whether the eye-centering phenomenon can be observed in environments that more closely reproduce gaze behavior during driving.

The present study investigated the occurrence of the eye-centering phenomenon while participants viewed driving videos and examined its applicability for detecting attention decline. Twenty-one healthy adults participated in the experiment. Driving scenes recorded on public roads were presented on a large display designed to provide a wide visual angle. Participants were instructed to observe the videos as if they were driving. A state equivalent to inattention was induced using a Q3A task, which required participants to continuously process an auditory sequence of letters and respond to specific target patterns. Two levels of cognitive workload were implemented: an easy condition and a hard condition.

Eye movements were recorded using Tobii Pro Glasses 3 at a sampling frequency of 100 Hz. To quantify the eye-centering phenomenon, the root mean square (RMS) of horizontal gaze displacement relative to each participant's mean gaze position was calculated. Horizontal gaze behavior was analyzed because horizontal eye movements are known to dominate visual exploration during driving-related tasks. RMS values were computed using sliding windows of 5 s with a 2.5 s overlap and subsequently averaged across each trial.

The results demonstrated a systematic reduction in RMS during the cognitive distraction conditions compared with the control condition, indicating a narrowing of the gaze distribution toward the visual-field center. Using percentile-based thresholds derived from control trials, attention decline was successfully identified in 77.8% of the easy-task trials and 81.0% of the hard-task trials. The higher detection rate obtained under the hard condition suggests that increased cognitive workload intensified the eye-centering phenomenon.

These findings provide evidence that the eye-centering phenomenon can emerge in a driving-video environment that better approximates natural gaze behavior during driving. A possible explanation is that concurrent cognitive processing interferes with the generation of eye-movement commands required for visual exploration, thereby reducing gaze excursions away from the straight-ahead direction. The observed decrease in horizontal gaze RMS under cognitive distraction is consistent with this interpretation.

In conclusion, the present study confirmed the occurrence of the eye-centering phenomenon during the viewing of driving videos and demonstrated the feasibility of using gaze-position information to detect attention decline. The proposed approach achieved detection rates exceeding 77%, suggesting that eye-movement characteristics may serve as a practical indicator of cognitive distraction. Future research should evaluate the robustness of the proposed method under conditions that more closely resemble real-world driving and investigate its applicability to in-vehicle driver monitoring systems.