

Metrics for estimating driver inattention in level 2 automated driving

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Research and development in automated driving have advanced significantly in recent years. Level 2 (L2) automated driving, in particular, is expected to play a major role in the future automated-driving market. In L2 automated driving, the system performs most physical driving operations, while the driver, remains responsible for monitoring the surroundings and supervising the system. This division of roles may reduce the driver's attention to monitoring and shift attention toward driving-unrelated thoughts or activities. In this study, "inattention" is defined as reduced attention to monitoring the surroundings accompanied by immersion in thoughts unrelated to driving. The objective was to investigate metrics for estimating this state. The experiment was approved by the Research Ethics Committee of the Faculty/Graduate School of Science and Technology, Keio University.

The apparatus consisted of a driving simulator equipped with a six-axis motion platform and an eye-tracking system. The route was an approximately 18-km-long, three-lane highway, comprising straight sections and left and right curves. The experimental factors were driver state and secondary-task type. Driver state had three conditions: "Safe Monitoring," in which the driver monitored the surroundings in a manner regarded as safe; "Fixation Point," in which the driver fixated on a red circular target displayed ahead; and "Task," in which the driver performed a secondary task intended to reproduce a state in which attention shifts from monitoring to thought, allocating 10% of attentional resources to monitoring and 90% to the task. The fixation-point condition was designed to characterize gaze behavior when fixation was constrained, given that moving or newly appearing objects tend to attract visual attention. Two secondary tasks were used: a calculation task requiring short-term memory retention and processing, and a question task requiring retrieval from long-term memory. Because it required continuous memory retention, the calculation task was designated as the higher-workload task.

Measures included gaze behavior (saccade frequency and viewing time toward overtaking vehicles, mirrors, and driving-unrelated areas) and subjective ratings (NASA-TLX, self-awareness of inattention, self-rated awareness of the surroundings, and drowsiness). This paper reports viewing time toward overtaking vehicles and self-awareness of inattention for the safe-monitoring and task conditions. Forty men and women aged 20 to 47 years participated, and all participants provided informed consent. Secondary-task type was varied as a between-subject factor. The groups assigned the calculation and question tasks are hereafter referred to as the Calculation Group and Question Group, respectively.

Figure 1 presents the results for an approximately 7.5-min analysis segment containing straight and curved road sections. The calculation and question groups are labeled C_Group and Q_Group, respectively. Higher self-awareness scores (maximum, 7) indicate greater awareness of being inattentive. Viewing time toward overtaking vehicles was shorter in the task condition than in the safe-monitoring condition, particularly in the Calculation Group. Self-awareness of inattention was also higher in the task condition, with a larger increase in the Calculation Group.

The Calculation Group, which performed the higher-workload task showed shorter viewing times toward overtaking vehicles and

greater self-awareness of inattention. However, the Question Group showed lower self-awareness of inattention, despite a shorter viewing time toward overtaking vehicles (Figure 1). The results further indicate that when drivers become absorbed in driving-unrelated thoughts during automated driving, they spend less time viewing overtaking vehicles, which are moving objects within their field of view. Viewing time toward overtaking vehicles may therefore be a useful metric for estimating driver inattention in Level 2 automated driving.

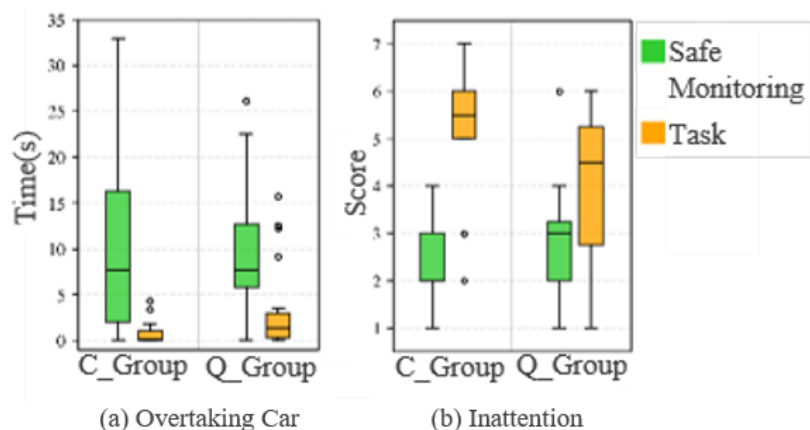


Fig1. Viewing time and subjective evaluation