The measurement of drivers' cognitive distraction and the management of their attention resource

INTRODUCTION

As a major cause of road traffic accidents, driver distraction (e.g., talking, reading or texting via cellphones while driving) contributed to about 25% of the total crashes. Along with the development of advanced in-vehicle information technology and the popularity of personal smart devices, driver distraction, especially cognitive distraction has been increased dramatically in recent years. Compare to visual and biomechanical distraction, cognitive distraction is much more difficult to be recognized since it doesn't show apparent exterior features such as a body motion or an eye transit from driving tasks to something else. Therefore, how to measure drivers' cognitive distraction in applicable ways is critical to develop driver state detection tools. From another perspective, the world's rapid progress to the era of connected vehicles and driverless cars requires a whole new design of "driver's tasks in car". Highly automated industries like nuclear and aviation have shown numerous accidents caused by loosing operators' attention due to too many or too little task demands. These lessons suggest that managing drivers' attention resource under a balanced scheme is important to future road safety.

METHODS

An observer's visual scanning behavior tends to narrow during periods of increased cognitive demand. Thus, measures of gaze concentration (Figure 1) have become a popular method of gauging cognitive demand, but the consensus on the best method for computing gaze concentration is still evolving. The author and related research team proposed multiple algorithms to calculate gaze concentration and tested them in both real road and simulated driving environment. The common research method for this topic includes inviting drivers from various demographic distributions to complete specific experiments via a road testing vehicle or a driving simulator. Driving behavior data and drivers' eye movement data will be collected (Figure 2). The increase of cognitive demand can be simulated either by surrogate psychological tests (Figure 3) or real interactive tasks between driver and the vehicle. The optimized methods to measure driver distraction and allocate driver attention resource will finally be located through statistical comparisons.

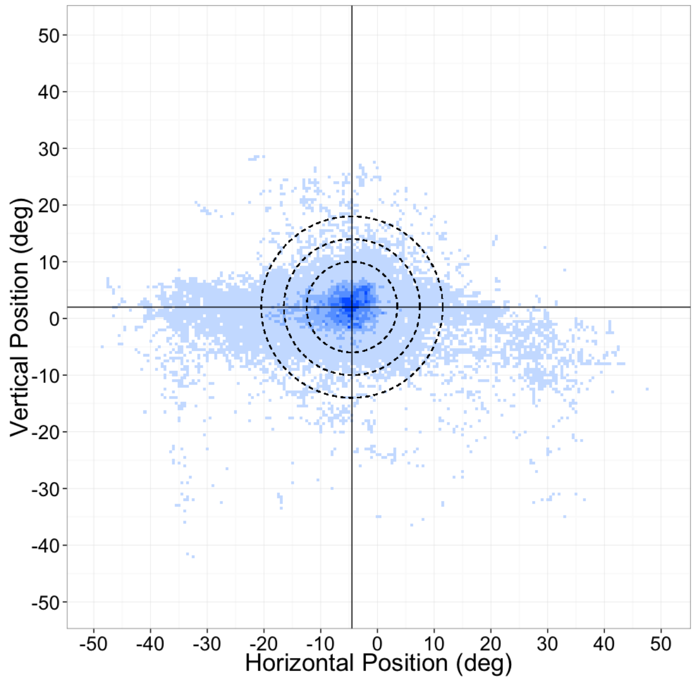

Figure 1: The distribution of driver's gaze position during driving and the gaze concentration effect.

Figure 2: The driving simulator and eye tracker working scenarios in Beihang University (pictures were clipped from a CCTV's interview to our research

group.)

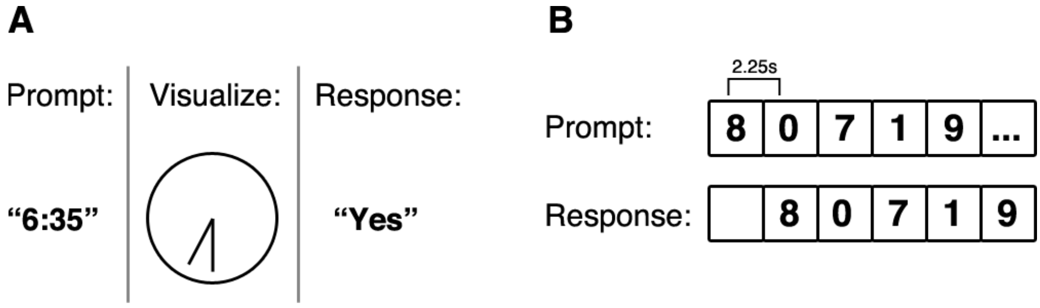

Figure 3: The surrogate psychological tests for stimulating drivers' increased cognitive demand (A. Clock Test – a visuospatial working memory task; B. 1-Back Test – an auditory working memory task).

RESULTS

We find Horizontal Gaze Dispersion (HGD), as measured from the standard deviation of horizontal gaze position, attained the largest effect size, indicating that it is the most sensitive to changes in gaze concentration under cognitive demand, while also being one of the simpler metrics to calculate. The proposed methods and our results show that complex eye tracking data sets from applied, ecologically valid situations such as on-road driving can be analyzed effectively with maximal sensitivity and minimal analytical burden to produce a robust measure of a driver's general allocation of attention. In addition, the team also designed multiple methods to optimize the balanced allocation of drivers' hand, eye, ear and brain cognition resources (Figure 4).

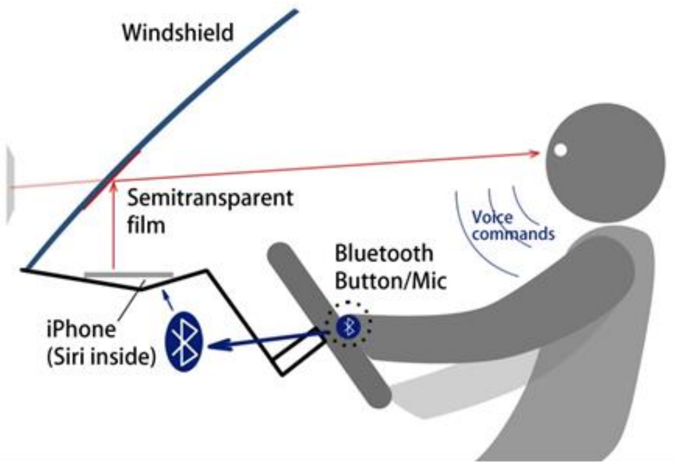

Figure 4: A human-vehicle interaction design aims to balance driver's hand, eye, ear and cognition resources.

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Reference

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