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A Pilot Study of the Influence of Illumination and Cognitive Load on Pupil Diameter in a Driving Simulator

Oskar Palinko
University of New Hampshire
Durham, New Hampshire, USA
oskar.palinko@unh.edu

Sahil Goyal
Indian Institute of Technology
Guwahati, Assam, India
s.goyal@iitg.ernet.in

Andrew L. Kun
University of New Hampshire
Durham, New Hampshire, USA
andrew.kun@unh.edu

ABSTRACT
To improve driving safety, it would be important to know the driver's cognitive load, which can be estimated based on changes in pupil diameter. We report on a study which had the goal to measure and dissociate between the effects of cognitive load and illumination on the pupil size. We propose a predictor of the pupil light reflex that allows more precise estimates of cognitive load.

Categories and Subject Descriptors
H.5.2 [**Information Interf. and Presentation**]: User Interfaces.

General Terms
Measurement, Design, Experimentation, Human Factors.

Keywords
Cognitive load, Pupillometry, Eye tracking, Driving simulator.

1. INTRODUCTION
Today, a rising number of in-car electronic devices draw away the driver's attention from the road. This can lead to hazardous situations. The drivers' cognitive state could be monitored to prevent these situations. One of the least intrusive methods for assessing cognitive load is measuring pupil diameter change using remote eye tracking. Because of the effect of task evoked pupillary response (TEPR), the pupil will dilate when a person is faced with a challenging cognitive task. But the pupil's diameter will also change based on light intensity (pupillary light reflex). Thus, it is important to measure the pupil's reaction to both and try to dissociate their effect. If illumination effects could be predicted, we would have a more precise cognitive load estimate.

2. RELATED RESEARCH
Recent research has showed that beside precise, head-mounted eye trackers, remote trackers can also provide good pupil diameter measures [1]. Our group has applied remote eye tracking in analyzing cognitive load in a driving simulator experiment [2]. In that study we took into account the influence of illumination with a general assessment, but not in detail. Here, we are exploring this effect in more detail.

3. EXPERIMENT
The experiment was completed by 5 members of our lab, who did not know about the purpose of the testing. They were given three different tasks while sitting in a driving simulator: aural vigilance task, illumination task and combined. The first task consisted of listening to a series of numbers in which every sixth could be out of order. The subjects needed to indicate this error by pushing a button. The illumination task consisted of the subjects looking at boxes of different levels of illumination (shades of gray), intermittent with dark, resetting periods. The third task combined the above two. We will focus on the first and second tasks here.

4. RESULTS
Aural vigilance results averaged over all subjects reveal a sharp increase in mean pupil diameter change when drivers experience high cognitive load (expecting to react to an error), Figure 1.

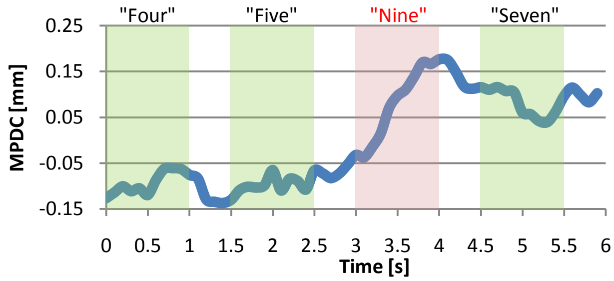

Figure 1 Mean pupil diam. change increase due to cogn. load.

Averaged illumination task results give us the pupil's step function response to the onset of illumination, Figure 2. This response allows us to design its transfer function.

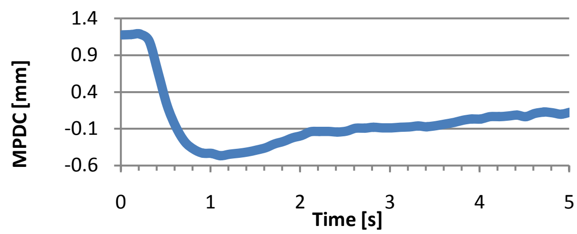

Figure 2. Pupil response to illumination step function.

5. FUTURE WORK
Building on the above results, we are working on designing a predictor of the eye's reaction to illumination (based on the model of the system in Figure 3) in order to get more precise estimates of cognitive load.

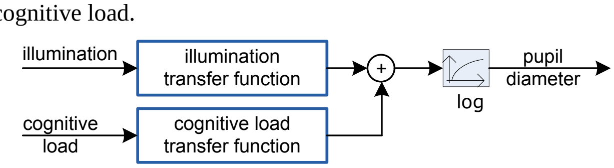

Figure 3. Pupil reaction model.

6. REFERENCES
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