ABSTRACT

TITLE: Effects of Lane Departure Warning on Drowsy Drivers´ Performance and State in a Simulator Experiment

OBJECTIVES:
Determine the correlation/relationships between drowsiness, lane departure events and effects of a warning system.

METHODS:
An homogeneous cohort of 63 young healthy males (22 to 27 years old) drove for approximately 2.5 hours in a mainly stimuli-deprived scenario in a static simulator (STI) to induce drowsiness. The driver sat in a fully equipped front half of a small car, controlling the car with a steering wheel with force feedback, brake and accelerator pedals. Comprehensive equipment for physiological measurements as well as detection and on-line analysis of eye closure and head movements (Seeing Machines and ASCI Inc.) was accurately synchronized with the simulator data. About one third of the subjects were assisted by an in-house lane departure warning (LDW) system they had never been exposed to before and that could be hardly tested in such dangerous situations in real traffic.

RESULTS:
The mainly monotonous driving task resulted in a successful drowsiness induction with several hundred micro-sleep episodes detected by electrooculogram (EOG) and video signal (eye closure percentage and PERCLOS) and confirmed by a double-blind behavioral analysis by a trained team of independent observers (Human Factors Consult, Berlin). Both the physiology measurements (heart rate, electrodermal activity EDA, electroencephalogram EEG and electromyogram EMG) and the records of the driving behavior (steering and breaking patterns) yielded a coherent picture of these events.
During the driving tests about 800 LDW alarms occurred. Afterwards, these alarms were analyzed and sorted according to the causes and situations in which they arose and the different subjects´ reactions to them, including habituation. Two highly significant sub-cohorts (80% vs. 20% of the subjects) could be identified regarding lane keeping performance. A combined analysis of the lane departure events with and without LDW showed significant reduction in the number, time, departure length and out-of-lane area for the assisted subjects. The timing and design of the warning signal could furthermore prevent almost 90% of the lane departure events caused by sleepiness.

CONCLUSIONS:
The different perspectives of the recorded data yield a coherent picture of significant events during the trials. In particular, the high number of sleep and drowsiness episodes confirms that the experiment design causes sufficient drowsiness to be able to measure its effects. It can be shown that the LDW system strongly reduces the number and severity of the lane departure events even in case of a micro-sleep episode. A first overview of the saccade and steering behaviors after an alarm suggests an acoustic-driven type of reaction before the visual attention can be focused on the „new“ scene. The habituation issue will be further addressed in future experiments.

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