eego™ sports

The total mobility solution

Showcase:

Effects of partially automated driving on the development of driver sleepiness

ant neuro
inspiring technology

The **eego**™ sports project showcase: Effects of partially automated driving on the development of driver sleepiness

Christer Ahlström, Raimondas Zemblys, Herman Jansson, Christian Forsberg, Johan Karlsson, Anna Anund

Prof. Dr. Christer Ahlström *is a senior researcher at the Swedish National Road and Transport Research Institute (VTI) and an Associate Professor in Biomedical Engineering at Linköping University. He primarily works with acquisition, processing, and analysis of data, with particular interest in biomedical engineering aspects of driver inattention and driver sleepiness. He has a master's degree in Computer Science and Engineering (2002) and a PhD in Biomedical Signal Processing (2008) from Linköping University, Sweden.*

The research

Christer and his colleagues aim at investigating the physiological mechanisms related to driver sleepiness. This study investigates whether partially automated driving, effects driver sleepiness and if so how. A mobile **eego**™ sports system was employed to measure brain activity from participants while actively driving.

What is the relevance and novelty of the current study?

Regularly car crashes happen as a result of fatigue. The contribution of fatigue to car accidents is about 15-25%. Fatigue crashes mostly occur in the nighttime or in the morning hours when drivers experience maximum drowsiness after staying awake for long periods of high or when the circadian sleep pressure is high. In partially automated vehicles available today, the driver is responsible and obliged to monitor traffic, while at the same time being relieved from the actual driving task (steering and using the pedals).This transformation of the driving task from active driving to active monitoring may lead to increased levels of fatigue due to monotony and boredom in combination with demanding attentive monitoring.

How was the experiment conducted?

Sleepiness was measured with subjective (i.e., rating scales) and objective indicators (i.e., physiological measurements, and electroencephalographic (EEG) measurements with the **eego**™ sports solution). Each study participant drove for about 2 hours on a public highway, both during the day when well-rested and later at night after being awake since early morning. This was done twice, both in a manually driven car and in a level 2 partially automated vehicle. The results suggested that the driving assistance system enhanced sleepiness, especially during night-time.

How did the physiological data provided by the **eego**™ sports solution inform about the fatigue state of the participant?

The **eego**™ sports solution comprises of an EEG system which is completely mobile and has an integrated, rechargeable battery. This allowed Christer and his colleagues to perform long-term EEG recordings. The additional sense box allows for simultaneous and synchronized recordings of other physiological signals such as ECG and EOG.

The following figure from Ahlström et al. (2021) illustrates how different sleepiness indicators vary as a function of the type of car (manual vs. partially automated) and day/night conditions. Specifically, EEG theta band activity increased when the brain state was deeply relaxed, focused inwardly and when the body prepared for sleep.

Sleep indicators

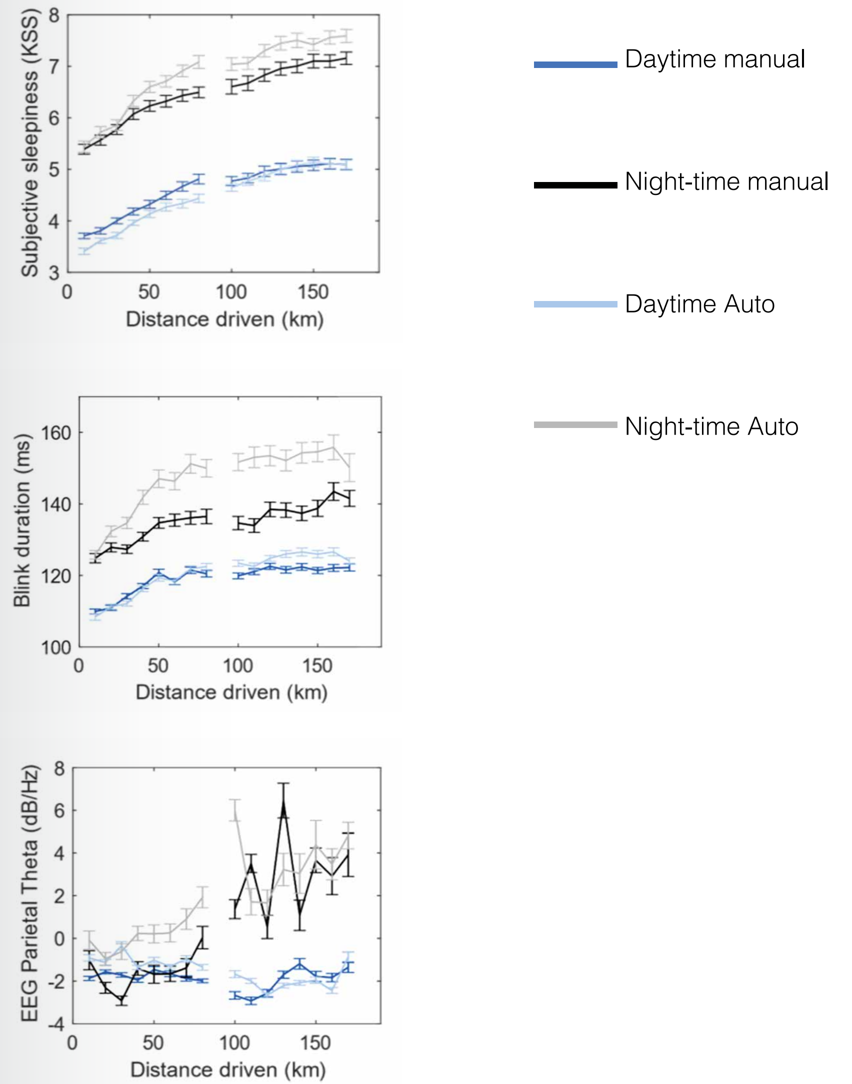

Figure 1*. The different sleepiness indicators (subjective sleepiness on the Karolinska sleepiness scale, blink durations and theta frequency band) are differently distributed depending on the driver's condition and the type of driven car.*

Interview

Could you elucidate the background which led to your research question?

VTI started doing experiments with sleepy drivers about 20 years ago. In the beginning we used our advanced driving simulators, then we started doing experiments on test tracks and eventually also on public roads. The journey has been invaluable to us. We have learnt that the high external validity that we achieve on public roads is needed to truly capture the drivers' struggle to stay awake. We always use vehicles with dual command and trained professional safety drivers, and we have permission from the Swedish government that allows us to run experiments with sleepy drivers on public roads.

Partially automated driving was devised with the aim to provide support and assistance to the driver. Do these supporting mechanisms pose a challenge and what are foreseeable complications?

These intermediate levels of automation and assistance are problematic. The driver is responsible and obliged to monitor traffic, while at the same time being relieved from the actual driving task (steering and using the pedals). This change from active driving to active monitoring may give rise to conditions like task related fatigue, sleepiness, boredom, or cognitive load. Attentive monitoring without an active task is demanding and will eventually affect operators' processing ability and performance.

It is however difficult to speculate on the impact of partial automation on fatigue-related crashes. An increase in passive fatigue would lead to more crashes, but at the same time, automated functionalities such as lane and distance keeping systems may prevent these crashes from happening.

How do you think underload and boredom could be counter-acted while driving a partially automated car? Are you planning research on this topic?

It has been claimed that the best way to keep a driver alert in an automated vehicle is to let him/her drive (Thomas Dingus, Fatigue Conference,2017). While there is a lot of truth to this statement, that would also hold back the many advantages with today's active safety systems. An alternative is to use some sort of preventive countermeasure that helps keeping the driver alert and focused on the driving task.

What are countermeasures?

Fatigue countermeasures aim to prevent the driver from becoming too fatigued, or to correct and alert the driver when fatigue occurs. Countermeasures are available at many levels, from public awareness campaigns or roadside initiatives, via work scheduling and fatigue risk management, to driver support and intervention systems in the car. Most drivers are already aware that they are sleepy, so an important aspect of countermeasures is to present alternatives and solutions, such as guidance to the nearest rest stop.

Figure 2. *Photo by Maria Elvåker, VTI*

External links

ANT Neuro website: www.ant-neuro.com

waveguard™ caps: www.ant-neuro.com/products/waveguard_caps

eego™ sports solutions: www.ant-neuro.com//products/eego_product_family

References

1. Ahlström, C., Raimondas , Z., Jansson, H., Forsberg, C., Karlsson,J. & Anund, A. (2021). Effects of partially automated driving on the development of driver sleepiness. Accident Analysis and Prevention, 153. doi: https://doi.org/10.1016/j.aap.2021.106058

2. 10th International Conference on Managing Fatigue, San Diego, March 20-23rd, 2010; https://fatigueconference2017.com

eego™ amplifiers are CE marked medical devices, according to MDD 93/42/ EEC, class IIa, and have FDA clearance under 510(k). **wave**guard™ caps are CE marked medical devices, according to MDR (EU) 2017/745, CE class I, and have FDA 510(k) clearance. Manufactured by eemagine Medical Imaging Solutions GmbH, Berlin, Germany, ISO 13485 certified. ANT Neuro and eemagine are part of the neuromotion group.

ANT Neuro b.v., Hengelo, The Netherlands,
tel: +31 (0) 850 498 175, fax: +31 (0) 850 493 919,
internet: www.ant-neuro.com, e-mail: info@ant-neuro.com

https://www.ant- neuro.com/products/eego_sports
https://www.ant-neuro.com/products/waveguard_original

inspiring technology