Analysis of Naturalistic Driving Data to Assess Distraction and Drowsiness in Drivers of Commercial Motor Vehicles

OVERVIEW

The objective of this study was to reduce and analyze previously collected heavy-vehicle naturalistic data to better understand crashes involving heavy-vehicle drivers and the impact of distraction and fatigue on commercial motor vehicle (CMV) operations. The study examined safety-critical events (SCEs) in the context of driver behaviors and fatigue.

STUDY APPROACH

Over 3.8 million miles of naturalistic data were collected from 7 fleets and 10 locations under the original Onboard Monitoring System Field Operational Test (OBMS FOT) study. Data were collected continuously from cameras and from kinematic sensors. The kinematic data were processed with a set of sensor trigger values to identify SCEs. These recorded events were reviewed manually to ensure SCE validity and to sort them into categories:

1. Crash
2. Near-crash
3. Crash-relevant conflict
4. Unintentional lane deviation

Video data, gathered from camera views as illustrated in Figure 1, were analyzed to identify various driver behaviors and fatigue levels. The study calculated odds ratios (ORs) for a range of tasks—that is, the odds of being involved in an SCE associated with a given task compared to the odds of being involved in an SCE without that task present. Table 1 below is an excerpt of the odds ratio results from the report. Note that odds ratios greater than one represent a positive association with SCEs, whereas odds ratios less than one represent a negative association with SCEs.

The study also examined correlations between glances away from the roadway and SCEs, a category that partially overlaps with the task-oriented questions; several secondary tasks, such as browsing on a mobile phone, result in a driver looking away from the forward roadway.

The study also examined the extent and safety effects of drowsiness within the contexts of driving hour (relative to the beginning of the shift) and distraction (whether a given secondary task tends to support or degrade alertness). Drowsiness was measured via two methods: observer rating of drowsiness (ORD), a subjective rating based on video observation of a driver; and percentage of eye closure (PERCLOS), an objective measure of the proportion of time a driver's eye are closed.

Figure 1. Five camera views representative of those used in the study.

FINDINGS

This process resulted in 4,102 valid events and 14,198 baseline epochs (normative driving). Researchers used these data to explore eight research questions, which are described in detail in the report itself.

Some tasks were found to increase safety risks while others reduced it. In general, safety-improving tasks involved mental or physical activity (e.g., speaking on a hands-free device or to a passenger, singing along to music) but did not encumber a driver's hands or take their eyes off the roadway. Safety-degrading tasks tended to involve the eyes and/or hands: reaching for object, texting or browsing the internet, interacting with electronic dispatching devices, or adjusting mirrors.

The time-of-the-day of the trip could affect drivers' drowsiness. Fatigue was highest in systematic baselines and SCEs from 1 a.m. to 6 a.m.

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Table 1. Odds Ratios (ORs) and 95-percent confidence interval of secondary tasks during SCEs and baseline epochs across all events for motorcoach and truck data.

Secondary Task	Motorcoach OR	Motorcoach LCL**	Motorcoach UCL**	Truck OR	Truck LCL**	Truck UCL**
Secondary Task (Overall)	**1.56***	1.39	1.75	**1.22***	1.10	1.35
Talking/singing	1.17	0.95	1.46	**0.60***	0.47	0.76
Simulated “dancing” while in driver’s seat	**0.37***	0.16	0.83	**0.40***	0.24	0.67
Reading	2.04	0.80	5.25	**3.27***	1.63	6.59
Passenger	0.97	0.70	1.34	0.90	0.39	2.09
Reaching for object	**2.46***	1.57	3.86	**4.57***	3.27	6.39
Intercom use (motorcoach)/Electronic dispatching device(truck)	**2.74***	1.49	5.03	**1.44***	1.05	1.98
Other electronic device	1.01	0.49	2.08	**2.87***	1.54	5.36
Adjusting instrument panel	**1.34***	1.03	1.75	0.97	0.78	1.21
Adjusting/monitoring other devices integral to vehicle	**1.59***	1.07	2.38	**3.31***	2.24	4.89
External distraction	**1.57***	1.29	1.93	**1.21***	1.04	1.41
Reaching for food- or drink-related object	0.86	0.43	1.74	**1.67***	1.19	2.33
Eating	1.18	0.77	1.80	1.11	0.88	1.40
Drinking from container	0.90	0.43	1.87	0.87	0.57	1.31
Personal grooming	1.41	0.96	2.07	0.84	0.60	1.18
Removing/adjusting clothing	**2.29***	1.27	4.13	**3.01***	1.72	5.27
Other personal hygiene	**2.23***	1.39	3.57	0.90	0.67	1.20

*Asterisk indicates a significant OR. These ratios are also shown in bold. Note that ORs greater than one represent a positive association with SCEs, whereas ORs less than one represent a negative association with SCEs.

** Lower confidence limit and upper confidence limit.

CONCLUSIONS AND STUDY LIMITATIONS

As in any research study, and especially with naturalistic driving data, there are limitations on this study's scope and application. One noticeable limitation when considering driver drowsiness research is that none of the studied fleets were dedicated over-the-road operations and therefore few of the drivers drove extended hours. While the OBMS FOT aimed to collect data from a representative sample of fleets and drivers for 1 year each, four fleets collected data for less than 6 months and three of those for less than 3 months. Thus, the majority of collected data came from mostly local and regional fleets. The methods employed in this study lay groundwork for future research into over-the-road operations tending toward longer hours, but they are not a substitute for research based on a wider sample of drivers.

Despite this limitation, over 3.8 million miles of data were collected that provide valuable information. For example, the study provides insights into the two fatigue measures used to quantify drowsiness. There were more instances of ORD drowsiness than PERCLOS drowsiness in the data, indicating that human observers reading body language and other general signs of fatigue identified more instances of drowsiness than did a metric based on eye closures. This distinction does not prove that one method or the other is more accurate, but it does mark a distinction between quantitative, objective measures and a more holistic approach. One possible explanation for the discrepancy is that the ORD method may identify moderate drowsiness more consistently than does PERCLOS, because drivers maybe begin to show other signs of fatigue before experiencing frequent or prolonged eye closure. Further research into distinctions between ORD and PERCLOS—and simple awareness of these distinctions—may be useful in shaping future research into driver drowsiness.

To read the complete report, please visit: https://rosap.ntl.bts.gov/view/dot/57153