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Determining the sampling time frame for In-Vehicle Data Recorder measurement in assessing drivers

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ABSTRACT

The present paper describes a method for choosing a sampling time frame for an In-Vehicle Data Recorder (IVDR) as an assessment tool in analyzing driving patterns and changes in the behavior of drivers over time. The study was a short-term follow-up to assess the driving patterns of 64 cab drivers. IVDRs installed in the vehicle of each participant recorded detailed information about undesirable events that occurred during the trip regarding the position of the vehicle, its speed, vertical and horizontal acceleration, and maneuvers. A statistical analysis was carried out on the IVDR data to identify the time at which the rate of driving events stabilizes in order to find a reasonable sampling time frame. The analysis indicates that collecting a sample of ≈300 h per driver should result in a relatively stable and reliable measure for assessing the driver's average event rate, and that sampling less than 100 driving hours per driver does not result in a reliable measure. Sampling between 100–300 h may also result in a stable measure but it is less recommended. The advantage of IVDR monitoring technology is that it makes it possible to evaluate changes over time and use the results to create custom-tailored interventions that can be implemented on different driving populations such as professional drivers, drivers with ADHD, new drivers, and others.

1. Introduction

Driving assessments generally include both off-road and behind-the-wheel components (Stav, 2004). Off-road driving assessment involves a driving history check, vision and physical assessment, assessment of cognitive and perceptual capabilities, and examination of the knowledge of current road laws and rules. The off-roads assessment is based on computerized and pen-and-paper evaluations, self-report questionnaires, and interviews. Although these assessments cost relatively little, they are subject to potential biases (Podsakoff and Organ, 1986; Maycock et al., 1991). They are conducted in a clinical setting rather than in the distracting arena of motor vehicle traffic, which raises doubts about their reliability to reflect actual driving behavior in the real world. On-road assessments, by contrast, can take place in the person's own car or in that of the driving assessor to measure driving performance against licensing authority standards and to assess the ability to drive safely and legally. Although behind-the-wheel evaluation is considered to have ecological validity, it does not always succeed in obtaining information about personal attributes that are difficult to observe directly during the test (Classen et al., 2010). These limitations indicate the need for other, more reliable sources of detailed objective information about individuals' real-time driving, in order to assess driving behavior when confronted with various traffic conflicts and to monitor infringements of the law.

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With recent advances in monitoring technologies, a new generation of data collection methods has become available to evaluate actual driving behavior continuously in great detail and with the possibility of large-scale implementation.

In-Vehicle Data Recorders (IVDR) are electronic monitoring devices installed in the vehicle that for the first time make possible accurate recording of driving data over a long period of time for the study of driving patterns (Shiftan and Toledo, 2008). Data collection of events over many hours of driving can assist in assembling a driving profile for drivers by evaluating driving behavior through the definition of events (i.e., hard braking, accelerating, sharp turning and speeding) related to these measurements (Albert et al., 2011). Note that previous studies show that regardless of the type of measurement technology, speed and hard braking are associated with higher accident rates (Klauer et al., 2008; Simons-Morton et al., 2009; Kloeden et al., 2001; Aarts and van Schagen, 2006). Monitoring an individual driver's propensity to indulge in such behaviors enables the technology to calculate a risk rating for that driver (RoSPA, 2013).

The validity of IVDRs for the promotion of safety has been established based on observations of 103 drivers in 18,173 trips and a total of 8430 driving hours (Musicant et al., 2007). Past driver involvement in car crashes was collected for three years preceding the installation of the IVDR. Next, based on IVDR records the drivers were classified into three risk categories: moderate, intermediate, and aggressive. The results showed significant correlations between past car crash involvement and the IVDR data (Musicant et al., 2007). Toledo et al. (2008), using a different set of data based on the same IVDR technology, found similar results and concluded that IVDR data is a reliable source for studying driving behavior and vehicle usage.

Nevertheless, when we evaluate the behavior of drivers using the IVDR, there is not enough evidence-based research addressing the right amount of time (the "sampling time frame") needed to identify driving patterns or evaluate the improvements achieved by intervention programs over time (Musicant et al., 2011). An aspect indirectly related to this issue has been studied since the 1960s (Perkins, Harris, 1968; NCHRP, 1999), with researches trying to answer the question of how long a site should be observed to obtain reliable estimates of conflict rates (rates of traffic events involving the interaction of two or more drivers, where one or both drivers take evasive action to avoid a collision) (Robertson et al., 1994; Parker and Zegeer, 1988).

Reviewing the recent literature on the assessment of driving behavior using the IVDR, we find that there is no consensus about the reasonable sampling time for IVDR measurement in the assessment of drivers. Many studies that have used IVDR, report on a variable range that includes 80 h (Musicant et al., 2007), 400 h (Neale et al., 2002), and 2107 h (Musicant et al., 2011) per driver.

Driving patterns have been examined by Musicant et al. (2010), who analyzed the event frequency of 117,195 trips, with duration of 2–90 min per trip over a 6-months period for 109 drivers. Using several regression models, the authors found higher event frequency at the edges of trips (beginning and end) than in the middle, and higher event frequency at night than during the day. These patterns are of interest at the level of the trip itself, but do not answer the question about the length of time needed for data collection and about the optimal sample time for obtaining the most accurate driving pattern for each driver.

The aim of the present study is finding a reasonable sampling time frame of the IVDR (i.e., long enough for identifying relevant patterns, but not too long, so that the length of future IVDR studies will be reasonable and feasible), by analyzing driving patterns and changes in the behavior of drivers over time, beyond changes of event rate between the edges of trips, driving hours, or days (e.g., morning rush hour versus night, workdays versus weekends). The sampling time frame of this study is aimed at identifying the personal risk level of the drivers.

In the present study we estimated the sampling time frame required for reaching a stable driving pattern by using the average event rate.

Two statistical analyses were carried out on IVDR data. The first analysis uses a convergence index to determine at what magnitude the data converge on the events rate in order to identify the time at which the rate of undesirable driving events stabilizes. The second analysis is that of the expected error, which was developed in order to assess the error a given sampling time frame produces when it is used to evaluate the driving pattern.

2. Material

The study was a short-term follow-up that used IVDR to assess actual driving patterns.

2.1. Participants

Sixty-four male volunteers who have professional driver's licenses and work as cab drivers were recruited. The mean age was 50 (SD = 10.8). The mean number of hours of driving per week was 55 (SD = 21.03). The drivers were monitored during a work period of a minimum of one month. Drivers who drove less than 2 h per day were excluded.

2.2. The IVDR used in the present study

The IVDR system evaluated in the present study was developed by Traffilog Ltd. The system focuses on driving safety and analysis of the technical skill of the driver, and provides a driving profile. The Traffilog Vehicular Unit (VU) is a relatively small box installed in a hidden place in the vehicle dashboard. The system forms and maintains a direct connection with