A SHRP 2 Safety Project Brief

Analyzing Driver Behavior Using Data from the SHRP 2 Naturalistic Driving Study

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Studies have long shown that the most significant factor in crashes is the driver. To date, however, the driver and the driver's interaction with the road, vehicle, and environment have been difficult to study in an objective way. A new method—naturalistic driving studies (NDS)—provides objective data, which transportation agencies can use to derive improved countermeasures and more effective uses of existing countermeasures to reduce crashes and improve roadway safety.

The second Strategic Highway Research Program (SHRP 2) is conducting the largest and most comprehensive NDS ever undertaken. The study has recruited more than 3,100 volunteer drivers, ages 16–80, at sites in six states: Florida, Indiana, North Carolina, New York, Pennsylvania, and Washington. All their trips are recorded for up to two years. Data include vehicle speed, acceleration, and braking; vehicle controls; lane position; forward radar; and video views to the front and rear of the vehicle and on the driver's face and hands. When complete in early 2014, the NDS data set will contain in excess of 33,000,000 travel miles from some 3,800 vehicle-years of driving—more than 4 petabytes of data.

In parallel, the Roadway Information Database (RID) will contain detailed roadway data on about 12,000 centerline miles of highways in and around the study sites, in addition to information on roadway features, crash histories, traffic and weather conditions, work zones, and active safety campaigns in the study areas from state data sources. The NDS and RID data can be linked to associate driving behavior with the roadway environment.

This project brief describes how NDS data can be searched. It also provides an overview of three SHRP 2 projects that are analyzing NDS and RID data to develop real-world safety countermeasures.

Trip Files

NDS data are stored in trip files, one for each of the study's 5 million trips. These files record each variable every time it is sampled: every 1/10 second for most variables, every 1/15 for video, every second for GPS, and so forth—a time history record of each trip from the time the vehicle starts until it is turned off. For example, a 10-minute trip would have on the order of 10 min $\times$ 60 sec/min $\times$ 10 samples/sec, or 6,000 records, with each record having about 100 different measures or data points. These trip files are very large and it would be time-consuming and expensive to search all the files to identify trips with specific characteristics.

To accelerate data searches and provide summary information, SHRP 2 developed a trip summary file. This file makes trips easier to find by capturing summary information in a

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single record for each trip. Some variables don't change during a trip, such as driver age and gender, vehicle type, and other descriptive information. Other variables can be replaced by summary measures computed over the whole trip, such as average speed, total distance traveled, time or distance traveled with speeds over 70 mph, or number of accelerations over some threshold. The file will include flags to indicate the presence of a crash or near-crash on the trip. The trip summary is a single file with one record per trip—5 million records for the whole dataset. This file can be searched relatively quickly to find trips with specified characteristics. The trip summary file will not contain personally identifying data, lends itself to a user-friendly web interface, and can be downloaded into common packages, such as Access. The file will include a trip ID so that full trip files can be located easily for further analysis.

Crash, Near-Crash, and Baseline Files

The NDS will include more than 700 crashes of various severities, ranging from those that produced major injuries or death to those when a vehicle struck a curb and continued driving. It will include about 7,000 near-crashes—incidents in which a crash would have occurred if the driver had not braked or steered abruptly at the last moment. Many studies will analyze these crashes and near-crashes to investigate what caused the crashes, what might have prevented them, what led to a near-crash situation, and how drivers in near-crashes avoided a crash.

SHRP 2 is producing crash and near-crash data files to assist these studies. These files will contain a record for each crash or near-crash and will be available to qualified researchers. The record, called an epoch, contains all relevant data for about 20 seconds before and 10 seconds after the crash or near-crash. In addition, SHRP 2 is producing baseline files of event-free driving with which to compare the crashes and near-crashes. The baseline files will contain similar 30-second epochs either selected at random from all NDS trips or records matched to crashes and near-crashes. For example, for a specific crash, epochs could be selected from the same driver's trips at the same time of day and day of week on the same or similar roads.

Data Analysis

In February 2012, four analysis contracts were awarded under SHRP 2 project S08 to study specific research questions using the early NDS and RID data. In the proof-of-concept Phase 1 of these projects, each contractor obtained small initial data sets from the NDS and RID, tested and refined their research plan, and developed detailed plans for their full analyses. Three contractors were selected for Phase 2, in which they will obtain and analyze a much richer data set; these studies will conclude by July 2014. Summaries of these three contractors' Phase 1 results follow. The results from these studies should lead to real-world countermeasures. These projects also provide examples of the types of analyses that can be conducted with SHRP 2 NDS and RID data.

The full Phase 1 report for this project (*Initial Analyses from the SHRP 2 Naturalistic Driving Study: Addressing Driver Performance and Behavior in Traffic Safety*) is available at http://www.trb.org/Main/Blurbs/168727.aspx or by searching the report's title at www.TRB.org.

Lane Departures on Rural Two-Lane Curves

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Rural two-lane curves pose a significant safety problem, and the interaction between the driver and the roadway environment in rural curves is not well understood. To learn more, this research is assessing the relationships between driver behavior and the roadway and environmental factors on rural two-lane curves and how these relationships affect the likelihood of lane departures.

Most highway agencies have implemented a range of countermeasures to reduce lane departures on rural two-lane curves. However, agencies have only limited information about the effectiveness of these countermeasures and even less information about why they are or are not effective.

In Phase 1, SHRP 2 NDS and RID data were used to develop initial models that explore how drivers interact with the roadway environment and what conditions are present when a driver does not successfully negotiate a curve compared to the when successful negotiation occurs. The full project will gain insight into where a driver's attention is focused during curve negotiation and what roadway cues—such as signs, chevrons, and pavement markings—are most effective in keeping drivers within their lane. The research has implications for roadway design, selecting and locating curve warning signs, and providing adequate sight distance.

The results of this research will help transportation agencies make better decisions about countermeasure selection. They will be useful to safety researchers; the American Association of State Highway and Transportation Officials (AASHTO); the Federal Highway Administration (FHWA); and state, county, and city transportation agencies.

Evaluation of Offset Left-Turn Lanes

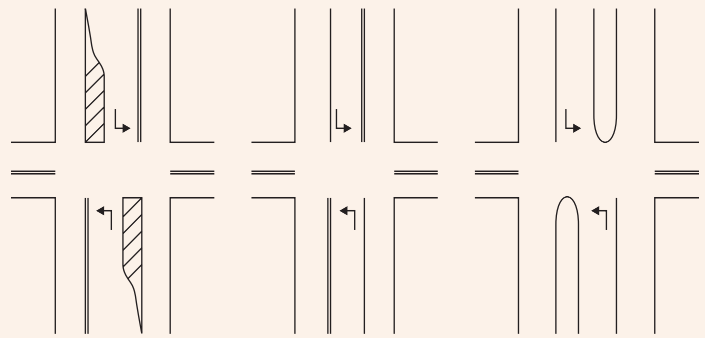
MRIGlobal

Left-turn lanes are used at intersections to provide a safe location for storing left-turning vehicles, out of through-traffic lanes, while their drivers wait for a suitable gap in opposing traffic to turn left. The provision of a left-turn lane minimizes the potential for rear-end collisions with through vehicles approaching from behind the left-turning vehicle and reduces the pressure on left-turning drivers to leave an exposed position and accept an inappropriate gap in opposing through traffic. However, vehicles in opposing left-turn lanes can block each other's view of oncoming traffic (see Figure 1, center diagram).

A geometric design solution for these sight obstructions is to offset the left-turn lanes (that is, to move the left-turn lane laterally within the median so that the opposing left-turn vehicles no longer block the sight lines of their drivers). The drawings in Figure 1 illustrate intersections with positive offset, zero offset, and negative offset for opposing left-turn lanes.

While the principle of offset left-turn lanes is accepted based on anecdotal evidence, there is no conclusive quantitative evidence of their effects on driver behavior or crash reduction or of how these effects vary with the width of the offset. This research project will determine if offset left-turn lanes affect gap acceptance behavior and improve safety for left-turning vehicles, as well as whether the presence of a vehicle in the opposing left-turn lane has an impact on the effect. Based on the small sample in Phase 1 that included just a few months of NDS trip data, it is estimated that the full Phase 2 study, which will include at least three times as many NDS driver trips, may yield on the order of 8,000 rejected gaps and 1,000 accepted gaps. With this dataset, the team will be able to determine if offset left-turn lanes affect driver gap acceptance behavior, as well as whether the

Figure 1. Illustration of positive, zero, and negative offset left-turn lanes (Persaud et al., 2009)



presence of a vehicle in the opposing left-turn lane has an impact on the effect.

The results from this research could be used to establish a minimum desirable offset for opposing left-turn lanes and to determine how that information can best be presented as design guidance for application by intersection designers. This guidance could be included in the AASHTO *Green Book* and state highway agency design manuals. These applications could have a direct impact on fatal and injury crashes that involve left-turn maneuvers, as well as on many less severe crashes.

Safer Glances, Driver Inattention, and Crash Risk

SAFER Vehicle and Traffic Safety Centre at Chalmers

Driver inattention has been the focus of significant national attention recently—in legislation, regulation, design guidelines, and information campaigns (see www.distraction.gov). The vehicle and electronics industries are moving rapidly to enable the use of electronic devices in a safe manner and to develop and implement systems to monitor driver inattention. In the past few years, two main developments have increased the priority of driver inattention: (1) There is a growing concern over the driving-compatibility of the ever-increasing availability and use of electronic devices such as smart phones and intelligent vehicle systems; and (2) research has shown a much clearer association between driver inattention and crash risk.

Unfortunately, the specific mechanisms and indicators of the risk of inattention are not well quantified. The most sensitive measures of risk are those which most precisely quantify an off-road glance that overlaps a change in the state of the driving environment or an action that began the sequence leading to a crash or near-crash, called the precipitating event (for example, a lead vehicle that begins braking). The longer the driver looks away from the road at this specific time, the greater the risk.

This research is developing a statistically validated set of inattention-risk functions (or relationships) describing how increased inattention in lead-vehicle pre-crash scenarios leads to increased risk. In particular, the relationships between inattention and risk can be used to show more precisely which glance behaviors are safer than others. For example, this research can be used to show how much the risk of a serious injury when tuning a radio or setting a vehicle control can be reduced by reducing the length of single glances, and it can relate this net benefit to the potential cost of increasing the number of glances needed to tune the radio. By studying these relationships, researchers can determine how this risk varies in different contexts (for example, stop-and-go versus free-flowing traffic), can determine the point in time where the eyes are needed most to control braking, and can be used to differentiate the type of glance behavior that leads to crashes from the type that leads to near crashes.

The results from this research can improve the scientific knowledge supporting driver distraction guidelines for in-vehicle electronic devices, which could have several applications. Results could be used to support evidence-based distraction policy and regulations, and to teach safe glance behaviors. The most dangerous glances could be pinpointed and associated with improvements to appropriate countermeasures, such as active safety system technology. This research also could lead to improved intelligent-vehicle safety systems, such as the forward collision warning systems. Making these systems inattention-adaptive could reduce nuisance warnings and deliver more precise warnings when the risk is greatest.

References

Persaud, B., C. Lyon, K. Eccles, N. Lefler, and F. Gross (2009). *Safety Evaluation of Offset Improvements for Left-Turn Lanes*, Report No. FHWA-HRT-09-035, Federal Highway Administration, Washington, D.C.

Naturalistic Driving Study website is at www.shrp2nds.us

Discussion Forum for the NDS is at http://forums.shrp2nds.us

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