

MPC-521

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Project Title:

Evaluating Relationships between Perception-Reaction Times, Emergency Deceleration Rates, and Crash Outcomes using Naturalistic Driving Data

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Research Needs:

Perception-reaction time (PRT) and deceleration rate are two critical factors in stopping sight distance (SSD). Since SSD is a critical design criterion (it controls vertical curve design and horizontal sightline offsets), the values of PRT and deceleration rate used in design have large impacts on both the safety and costs of the roadway system. PRT and deceleration rates are also used in crash reconstruction, which can impact the outcomes of lawsuits and tort liability.

Current *American Association of State Highway and Transportation Officials* (AASHTO) SSD guidance related to PRT and deceleration rate is provided in *A Policy on Geometric Design of Highways and Streets* (herein referred to as the Green Book) (1). These values are based on 90th percentile PRT and 10th percentile deceleration rate values from experiments that were completed in Texas in the mid 1990's (2). However, these experiments lacked real-world distractions that drivers are subject to, were limited in the age range and abilities of drivers, did not test a wide variety of initial speeds and lighting conditions that may impact PRT and deceleration rates, and did not account for potential correlations between the PRT and deceleration rates. Thus, the values from these experiments may not be applicable in real-world scenarios.

Recent research has used driving simulators and naturalistic data from the 100-car naturalistic driving study to evaluate PRT (3, 4). However, the sample sizes and conditions accounted for were limited. Also, the relationship between PRT and deceleration rate was not accounted for. Little research has been done that evaluates average emergency deceleration rates.

The *Strategic Highway Research Program 2* (SHRP2) recently implemented a multi-year naturalistic driving study (NDS) data collection effort that included over 3,400 drivers across the United States in an effort to address the role of driver performance and behavior in traffic safety.

This effort developed a database that researchers can use to assess driver characteristics and behaviors. This is a potential source that could be used to assess and develop models of the relationships between PRT and emergency deceleration rates. Given that data are available for crashes and near crashes, evaluation of the differences in PRT and deceleration rates for crash and near crash events may also reveal interesting differences that can be used to prevent crashes in the future.

There are likely multiple factors that influence the relationship between PRT and deceleration rate. The deceleration rate a person is likely to select (i.e., the intensity of brake application) in braking situations is likely to depend on the level of risk the driver perceives. Thus, there is potential that PRT has a direct impact on emergency deceleration rates. Large values of PRT may occur due to inattentiveness, yet the driver may brake harder due to an impending collision when compared to a shorter PRT for the same situation. Conversely, attentive drivers with long PRT may have low deceleration rates if they judge the conflict to be low risk (i.e., there is little urgency for either PRT or braking). Thus, high PRT may be associated with high deceleration rates when drivers are inattentive while attentive drivers are likely to have low PRT and high deceleration rates (for high risk situations) and high PRT and low deceleration rates for low risk situations.

Understanding the relationship between PRT and deceleration rate can improve transportation engineers understanding of human factors related to SSD, leading to improved design guidance and safer roadways. It could also improve crash reconstruction and the ability to determine what happened at crashes. Therefore, a study is needed to evaluate 1) the differences in PRT and deceleration rates between crash and near crash events and 2) the relationship between PRT and deceleration rates. The results of this research could be used by transportation agencies to improve design guidance. The results could also be used in crash reconstruction and for developing policies aimed at reducing the number and severity of crashes that occur on and near the roadway.

Research Objectives:

- 1) Evaluate the differences in PRT and emergency deceleration rates between crash and near crash events.
- 2) Determine the strength of correlations between PRT and emergency deceleration. Also, determine if there is a causal relationship between PRT and emergency deceleration rates and, if so, what the relationship is.
- 3) Develop a method and equations for predicting the PRT and deceleration rate for drivers that can be used for design and for crash reconstruction.

Research Methods:

The research objectives will be met through the execution of the work plan. Naturalistic driving data from the SHRP2 database will be used for evaluation. Statistical methods that account for unobserved heterogeneity, causal relationships, and other potential issues will be used. These may include random parameters models, Bayesian causal networks, matching methods, structural equations models, and other statistical and econometrics methods.

Expected Outcomes:

This research could identify relationships between PRT and deceleration rates that have not been previously investigated. Understanding these relationships could improve design guidance and safety for the transportation network. Also, understanding differences in PRT and deceleration rates between crashes and near crashes could be used to develop policies to improve the safety of the users of the transportation system. The results of the analysis will be used to develop equations for predicting PRT and deceleration rates that can be in design and for crash reconstruction.

Relevance to Strategic Goals:

The expected outcomes of this project are directly related to the following goals: Safety

Educational Benefits:

This project will provide valuable learning opportunities for two graduate students (one for two years and another for a single year) related to transportation engineering, human factors, and statistics/econometrics. It will also provide both students with the opportunity to travel to a conference to present the research and gain experience interacting with researchers and practicing engineers.

Work Plan:

The research objectives of this project will be met by completing the following tasks:

- 1) Perform a comprehensive literature review for PRT and deceleration rates related to design and crash reconstruction.
- 2) Using the SHRP2 NDS data, evaluate differences in PRT and emergency deceleration rates between crashes and near crashes. Account for personal and observation specific characteristics such as gender, age, initial speed, roadway type, weather conditions, conflict type, and other factors.
- 3) Based on the results of task 2, identify and discuss potential applications that could be used to improve transportation safety.
- 4) Using SHRP2 NDS data, evaluate potential correlations between PRT and emergency deceleration rates. Account for personal and observation specific characteristics such as gender, age, initial speed, roadway type, weather conditions, conflict type, and other factors.
- 5) Using SHRP2 NDS data, evaluate potential causal relationships between PRT and emergency deceleration rates. Determine if a causal relationship exists and, if so, what the relationship is. Account for personal and observation specific characteristics such as gender, age, initial speed, roadway type, weather conditions, conflict type, and other factors. Compare these results with the results from task 4.
- 6) Based on tasks 4-5, develop models for PRT and deceleration rate that can be used for roadway design.
- 7) Based on tasks 4-5, develop models for PRT and deceleration rate that can be used for crash reconstruction.
- 8) Compare the results of task 6 to existing design guidance and values for PRT and deceleration rate used in design.

- 9) Summarize all results and conclusions from tasks 1-8 in a final report. In addition, provide example applications for the results of tasks 3, 6, and 7. Discuss practical implementation strategies for each of the evaluations.

Project Cost:

Total Project Costs: \$180,258
MPC Funds Requested: \$75,000
Matching Funds: \$105,258
Source of Matching Funds: SDSU

TRB Keywords:

Safety, Stopping Sight Distance, Perception-Reaction Time, Deceleration Rate, Naturalistic Driving, Crash Reconstruction

References:

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