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Using naturalistic driving data to identify variables associated with infrequent, occasional, and consistent seat belt use

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ABSTRACT

Seat belt use is one of the most effective countermeasures to reduce traffic fatalities and injuries. The success of efforts to increase use is measured by road side observations and self-report questionnaires. These methods have shortcomings, with the former requiring a binary point estimate and the latter being subjective. The 100-car naturalistic driving study presented a unique opportunity to study seat belt use in that seat belt status was known for every trip each driver made during a 12-month period. Drivers were grouped into infrequent, occasional, or consistent seat belt users based on the frequency of belt use. Analyses were then completed to assess if these groups differed on several measures including personality, demographics, self-reported driving style variables as well as measures from the 100-car study instrumentation suite (average trip speed, trips per day). In addition, detailed analyses of the occasional belt user group were completed to identify factors that were predictive of occasional belt users wearing their belts. The analyses indicated that consistent seat belt users took fewer trips per day, and that increased average trip speed was associated with increased belt use among occasional belt users. The results of this project may help focus messaging efforts to convert occasional and inconsistent seat belt users to consistent users.

1. Introduction

1.1. Justification

An exploratory analysis of naturalistic driving data was conducted to understand variability of seat belt use between drivers and for the same drivers over time. As emphasized by Hedlund et al. (2004), considerable progress has been made in the United States with respect to getting drivers to wear seat belts, and it may be increasingly difficult to convince those who still do not wear their belts to buckle. In contrast, a strategy identified by the National Highway Traffic Safety Administration (NHTSA) (1998) is to focus efforts on getting drivers who occasionally buckle their seat belts to do so more consistently. Hedlund et al. suggest that gaining a thorough understanding of which drivers are not buckling and why they are not buckling is now a critical step in moving the driving population closer to 100% belt use.

1.2. Measures of seat belt use

Increasing the prevalence and consistency of belt use has been a major goal among traffic safety professionals, and efforts to achieve this goal include identifying variables that reliably distinguish between individuals who do and do not buckle, planning and executing education and enforcement programs, and using various methods to track changes in use. The emphasis on these efforts exists because of the effectiveness of seat belt use in saving lives and reducing injuries. The National Highway Traffic Safety Administration (NHTSA, 2011) estimated that for front seat riders of passenger cars, proper seat belt use reduces the risk of death from crashes by 45%. In 2009, wearing a seat belt saved the lives of approximately 13,000 passenger vehicle occupants in the United States. The collective efforts have led to incremental gains in belt use rates, with the most recent national usage estimate reaching 85% (NHTSA, 2010).

Traditionally, NHTSA derives its seat belt use rates by completing observational surveys (National Occupant Protection Use Survey or NOPUS), in which trained observers record seat belt status for drivers and passengers while vehicles are on the roadways. The survey, which has been conducted yearly since 1994, samples a random selection of major and local roadways from each region in the United States. The observations yield a stable measurement of daytime seat belt use. A limitation of the NOPUS method is that

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it is a single observation of one driver at one point in time. Given the method, observers cannot possibly know how the seat belt use pattern of a particular driver varies over time.

Two possible methods of addressing this limitation are to either ask individuals about their seat belt use patterns (self-report), or to observe individuals repeatedly over time. As an example of the first method, NHTSA (2008) conducted the Motor Vehicle Occupant Safety Survey (MVOSS), most recently in 2007. Six thousand individuals completed this survey and indicated, using a 5-point Likert scale response, whether they wear their seat belts "all of the time," "most of the time," "some of the time," "rarely," or "never." In the 2007 survey, 88% of drivers reported wearing their seat belt "all of the time," although 6% of those drivers admitted to not wearing a seat belt at least once in the past week. At the other end of the scale, 2% of respondents reported that they "never" or "rarely" wear a seat belt, and 10% reported that they wear a seat belt "some" or "most" of the time.

The second method was performed by McClafferty and Hankey (2010) as one analysis of the 100-car study dataset. The 100-car study, funded by NHTSA (Dingus et al., 2006), was a longitudinal, naturalistic study that recorded video and driving metrics for every trip taken by over 100 drivers over approximately a one year span from 2003 to 2004. Naturalistic driving research has limitations, such as small sample sizes relative to large-scale surveys and concerns about potential Hawthorne effects. However, the method is a powerful tool for traffic safety researchers. For example, McClafferty and Hankey, like the MVOSS survey, identified a large group of drivers who consistently wore a seat belt, yet the 100-car data yielded quantitative estimates of occasional and infrequent use as well. The 100-car dataset, although not representative of the United States' driving population, suggests that a higher percentage of drivers who self-report consistent seat belt use may actually fall into the less consistent seat belt use categories. Notably, direct comparisons between these two methods are not ideal since the Likert scale used in the MVOSS was more of a subjective interpretation that did not have quantitative anchors (i.e., "some of the time" in the MVOSS survey did not necessarily correspond to "less than 20% of the time" in the 100-car study).

1.3. Assessing seat belt usage with naturalistic data

Naturalistic driving research is a relatively new data source. The 100-car study was the first of its kind, instrumenting 100 vehicles in the Northern Virginia and Washington, DC Metro area with sensing and recording equipment. The cars were driven for one year (2003–2004) in everyday driving conditions by 108 primary and 299 secondary drivers (Dingus et al., 2006; McClafferty and Hankey, 2010). Primary drivers were the original participants of the study; secondary drivers were other drivers who used the primary driver's vehicle. Seventy-eight percent of the drivers in the study owned their own vehicles. The remaining vehicles were leased and provided to participants. The 100-car study oversampled for younger drivers (34% of the sample was aged 18–24), and participants were not excluded due to prior traffic convictions. Thus, although risk seeking drivers may have avoided participating in the study due to the video and other data recording, the recruitment procedures were not biased to exclude such drivers. In all, over 150,000 driving trips were recorded. Continuous data were collected for each trip in the dataset starting approximately 2 min after the ignition was engaged until the ignition was disengaged. This 2-min delay in starting data collection was due to startup procedures of the data collection system. Associated with each of these trips were parametric data collected from the vehicles (e.g., speed, acceleration), and videos of the driver's face (illuminated by an infrared light at night), dashboard, forward and rearward roadways.

The data collected by the 100-car study provided the opportunity to study many driving-related research questions, including those about causes of crashes, distracted driving, and seat belt use. A preliminary investigation into seat belt usage based on the 100-car video data coded seat belt usage for each trip according to the condition observed: Either yes (seat belt worn), or no (seat belt not worn) (McClafferty and Hankey, 2010). Analysts determined usage for a trip at the beginning of every trip made by each driver. Due to the 2 min boot-up period of the data collection system, the start of the trip file usually occurred shortly after the driver had left a driveway or parking lot and had begun driving the intended route. This delay means that seat belt usage of 100-car drivers was recorded in accordance with Malenfant and Van Houten's (2008) observations that most drivers (99%) who buckled their seat belts did so within the first 30 s of placing the vehicle in gear. Changes in seat belt usage later in the trip (putting it on or taking it off) were not considered in the current study.

In addition to the video and driving performance data, the 100-car primary drivers completed several questionnaires during recruitment and debriefing that supplement the naturalistic data. Of this supplemental data, the following were used in this study: the NEO Five Factor Inventory (NEO-FFI), the Dula Dangerous Driving Index (DDDI), the Driver Stress Inventory (DSI), and a questionnaire about demographics and self-reported driving histories. The NEO-FFI (Costa and McCrea, 1992) assesses the extent to which individuals demonstrate five personality domains: neuroticism, extroversion, openness to experiences, conscientiousness, and agreeableness. The five factor model has received support as a valid personality measure and has been shown to be predictive of behavior and performance on a variety of tasks (McCrae and Costa, 1987). The DSI measures drivers' attitudes about and tendency toward thrill seeking, aggression, dislike of driving, fatigue proneness, and hazard monitoring, and was shown to be significantly correlated with high-speed driving and traffic citations (Matthews, Desmond, Joyner, Carcary, Gilliland, 1996). Similarly, the DDDI has respondents rate, on a Likert scale, several items that load onto driving-related scores of aggressive driving, negative emotions, and risky driving (Dula, 2003). Finally, the 100-car questionnaires collected information including age, sex, educational attainment, traffic crash history, and self-reported seat belt use.

The psychometric properties of these measurement tools have been evaluated in past studies for their predictive value. Measurements of internal consistency of the NEO-FFI constructs resulted in Cronbach alpha coefficients ranging from .71 to .88 (Schwartz et al., 2011). Moreover, the NEO-PI-R, the extended instrument from which the abbreviated NEO-FFI was derived, has validity measures that compare the five domains with other adjectives ($r = .56–.62$), spouse ratings ($r = .44–.65$), and peer ratings ($r = .33–.48$) (Costa and McCrea, 1992). Similarly, the DDDI was found to have excellent internal reliability with total and subscale alpha coefficients ranging from .83 to .92. Temporal reliability was measured to range from 0.55 on the Aggressive Driving Scale to 0.76 on the Risky Driving Scale (Dula and Ballard, 2003). As these are reliable and valid measures that also covary with self-reported risk-taking, their inclusion in the 100-car study allowed us to conduct tests of their predictive effects on seat belt-related behavior.

1.4. Objectives

For the current analysis of seat belt use, the 100-car naturalistic and self-report data were used to achieve two objectives. The first objective was to determine if there were variables that uniquely characterized consistent, occasional, and infrequent seat belt users. An operational definition was developed to define these user groups, and this definition was used in an exploratory analysis to determine if and how the three user types differed from