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Driver behavior during bicycle passing maneuvers in response to a Share the Road sign treatment

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ABSTRACT

The interaction of motorists and bicyclists, particularly during passing maneuvers, is an area of concern to the bicycle safety community as there is a general perception that motor vehicle drivers may not share the road effectively with bicyclists. This is a particular concern on road sections with centerline rumble strips where motorists are prone to crowd bicyclists during passing events. One potential countermeasure to address this concern is the use of a bicycle warning sign with a "Share the Road" plaque. This paper presents the results of a controlled field evaluation of this sign treatment, which involved an examination of driver behavior while overtaking bicyclists. A series of field studies were conducted concurrently on two segments of a high-speed, rural two-lane highway. These segments were similar in terms of roadway geometry, traffic volumes, and other relevant factors, except that one of the segments included centerline rumble strips while the other did not. A before-and-after study design was utilized to examine changes in motor vehicle lateral placement and speed at the time of the passing event as they relate to the presence of centerline rumble strips and the sign treatment. Centerline rumble strips generally shifted vehicles closer to the bicyclists during passing maneuvers, though the magnitude of this effect was marginal. The sign treatment was found to shift motor vehicles away from the rightmost lane positions, though the signs did not significantly affect the mean buffer distance between the bicyclists and passing motorists or the propensity of crowding events during passing. The sign treatment also resulted in a 2.5 miles/h (4.0 km/h) reduction in vehicle speeds. Vehicle type, bicyclist position, and the presence of opposing traffic were also found to affect lateral placement and speed selection during passing maneuvers.

1. Introduction

In 2011, a total of 677 pedalcyclists were killed and 52,000 were injured in motor vehicle crashes in the United States (NHTSA, 2013). This represents a 9 percent increase in fatalities from 2010 as bicycle safety continues to be an emerging safety issue, particularly given trends that illustrate considerable growth in cycling activity (NHTSA, 2013; Pucher et al., 2011). These changes are reflected by increases in the use of bicycles for commuter purposes (Pucher et al., 2011), as well as a 16-percent increase in the proportion of fatalities involving bicyclists between ages 25 and 64 years since 2001 (NHTSA, 2012).

One area of concern to the bicycle safety community is the interaction of motorists and bicyclists, particularly during passing maneuvers. Approximately 59 percent of bicycle-involved fatalities occur at non-intersection locations (NHTSA, 2013) and there is a general perception that motor vehicle drivers often do not share the road effectively with bicyclists (Chapman and Noyce, 2012). However, research in this area is limited as a 2006 study notes, "practically nothing is known about what happens when overtaking maneuvers take place" (Walker, 2007). Additionally, a report from North Carolina indicates that "virtually no research has been conducted on rural roadways" where many of these overtaking maneuvers are likely to occur (Carter and Council, 2006). Despite this gap in the knowledge base, collisions during overtaking maneuvers are cited as one of the primary causes of bicyclist fatalities (Transport for London, 2005).

Several recent studies have been performed to attempt to discover more about this potentially risky interaction between motor vehicles and bicyclists. One such study employed a naturalistic experiment to gather proximity data from motorists overtaking bicycles on various highways in the United Kingdom (Walker,

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Fig. 1. Bicycle Warning Sign (W11-1) with "Share the Road" Plaque (W16-1) (FHWA, 2009).

2007). This study showed that vehicles tended to crowd bicyclists in instances where the bicyclists were closer to the motor vehicle traffic stream. Interestingly, motorists tended to provide more lateral buffer space to bicyclists perceived as females than males and less space when bicyclists were wearing helmets (Walker, 2007). A study performed in Taiwan utilized an instrumented bicycle to investigate the factors that affect the initial lateral passing distance, wheel angle, and speed control behaviors (Chuang et al., 2013). Lateral distance during passing events was shown to be smaller for motorcycles than for other motor vehicle types and motor vehicles tended to give more space to female bicyclists than males (Chuang et al., 2013). One notable aspect of this study, which differentiates it from previous work, is that the research considered the periods immediately before and after the overtaking event. A similar study using an instrumented bicyclist was performed in the United Kingdom, which investigated the lateral buffer distance between motor vehicles on highways with and without bicycle lanes (Parkin and Meyers, 2010). The results showed that vehicles tended to provide less lateral space in the presence of a bicycle lane, suggesting that vehicles drive within their marked lanes with less recognition for bicycle traffic in the adjacent lane (Parkin and Meyers, 2010).

Another recent study showed that centerline rumble strips reduce the overtaking distance between bicyclists and passing motor vehicles (Savolainen et al., 2012). However, the effects of the rumble strips were less pronounced than other related factors, including: the lateral placement of the bicyclists being passed; the number of bicyclists being passed; the presence of opposing traffic; and the type of motor vehicle involved in the overtaking maneuver (Savolainen et al., 2012).

One safety treatment that is aimed specifically at improving interaction between motorists and bicyclists is the bicycle warning sign (MUTCD W11-1), shown in Fig. 1, which can be used in conjunction with a "Share the Road" plaque (MUTCD W16-1). According to the Manual on Uniform Traffic Control Devices (MUTCD), the bicycle warning sign (W11-1) is intended to warn road users of unexpected entries by bicyclists into the roadway (FHWA, 2009). The "Share the Road" plaque may be added when there is a need to warn motorists about bicyclists traveling along the roadway (FHWA, 2009). Given the relatively low costs for providing such signage, research as to its effects provides valuable evidence to guide subsequent decision-making by road agencies. To date, no research has assessed the impacts of the W11-1 sign on driver behavior, though a similar pedestrian warning sign (W11-2) was previously shown to result in marginal improvements in driver compliance at select locations (Clark et al., 1996).

This paper examines the impacts of the combination of a bicycle warning sign (W11-1) with a "Share the Road" plaque (W16-1) on driver behavior while passing bicyclists. This study was completed in conjunction with another effort that investigated the effects of centerline rumble strips on the lateral placement of motor vehicles as they passed bicyclists on a two-lane rural highway (Savolainen et al., 2012). As rumble strips tend to shift motor vehicles away from the centerline, potentially crowding bicyclists, these types of locations represent good candidates for sign installation.

2. Methodology

A series of four field behavioral studies were conducted along two sections of Michigan Highway 109 (M-109), shown in Fig. 2, a two-lane rural highway in the northwestern Lower Peninsula, which serves as a popular bicyclist route. These sections included one location where centerline rumble strips had been installed and another location where rumble strips had not been installed. M-109 is unique in that it includes these two consecutive roadway sections, one with and one without centerline rumble strips, separated by approximately 1.1 miles. These segments possess similar geometric and traffic characteristics, including a relatively uniform driver population, creating an optimal setting for a controlled comparison. Each study segment is 0.5 miles (0.8 km) in length and includes 11 ft (3.4 m) wide lanes, a 4 ft (1.2 m) paved shoulder (neither site included shoulder rumble strips), and minimal horizontal or vertical curvature. Separate studies were conducted before and after the installation of the W11-1/W16-1 combination sign at each location. During both the pre- and post-installation studies, data were collected concurrently at the two study locations over a period of approximately 5 h. The first series of studies (prior to sign installation) were conducted on a Saturday in July of 2011. Several weeks later, the signs were installed on each study segment and post-installation data were collected along both segments on a Saturday in August of 2011. Two signs were installed at each study location (four signs total) as shown in Fig. 2. One sign was placed immediately upstream of each 0.5 miles (0.8 km) study segment in each direction. During the study periods, the weather was clear with temperatures of 81 F (27 °C) and 78 F (26 °C), respectively.

The principal objective of this study was to determine the impacts of the "Share the Road" sign combination on the lateral placement and speed of vehicles as they passed bicyclists. Conceptually, the study design is complicated by the fact that several external factors may also affect vehicle lateral placement and speed in such a setting besides the presence (or absence) of the sign treatment. Such factors include the following:

- *Lateral placement of nearest bicyclist to travel lane* – Bicyclists traveling nearer to, or within, the travel lane are expected to result in a greater lateral shifts and lower travel speeds by vehicles in comparison to when bicyclists are positioned farther outside the travel lane.
- *Number of bicyclists encountered* – Bicyclists riding in a group may be more conspicuous or elicit a different response from motorists than a bicyclist riding alone.
- *Type of motor vehicle* – Larger vehicles (e.g., trucks, buses, and recreational vehicles) require more space and, as such, may tend to shift over a lesser distance when encountering a bicyclist. The speed profiles for such vehicles are also likely to differ in comparison to passenger cars.
- *Presence of opposing traffic* – If traffic is present in the opposing lane, vehicles are inhibited from moving laterally and may be forced to slow down while passing or to crowd an adjacent bicyclist.