Operational and Safety Implications of Three Experimental Bicycle Safety Devices in Austin, TX

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ABSTRACT

Many cities in the United States are seeking ways to safely and effectively integrate bicycles into the urban transportation network. To address safety issues that arise along bicycle routes in Austin, Texas, this observational study examined the operational and safety implications of three new bicycle safety devices—Shared Lane Markings, “Bicycles May Use Full Lane” signs, and colored bicycle lanes at conflict areas—to determine what improvement in safety they offer. When the existing right-of-way cannot accommodate bicycle lanes, Shared Lane Markings and “Bicycles May Use Full Lane” signs improved the safety of bicyclists occupying the full lane by encouraging bicyclists to ride at a more central position in the lane, but did not always reduce unsafe bicycling behavior (like sidewalk riding or bypassing queues of stopped vehicles). Motorists at the study sites often provided greater space while passing and were less likely to pass bicyclists. Other safety concerns arise where a bicycle lane crosses a motor vehicle lane, such as at a freeway entrance ramp or where motorists accessing a right-turn bay must cross a bicycle lane. These conflict areas are traditionally dashed, but this study examined the improvement in safety that could be acquired by applying chartreuse thermoplastic to the dashed conflict area. Motorists were more likely to utilize turn signals when crossing the conflict area at all sites and were more likely to yield to bicyclists where the motor vehicle lane was guided across the conflict area.
BACKGROUND

As bicycle mode share increases, transportation and planning agencies seek ways to better integrate bicycles into the transportation network (1). Providing on-street bicycle facilities supports the U.S. DOT’s commitment to encouraging more transportation options in American cities, but surveys show that bicycling is viewed as unsafe by a majority of current and potential bicyclists (2). The addition of bicycle facilities to existing right-of-way has been met with a positive public response in the past (3). This report examines the safety and operational effects of three experimental bicycle safety devices studied in Austin, Texas between May 2009 and March 2010. The three devices—Shared Lane Markings, “Bicycles May Use Full Lane” signs, and colored bicycle lanes at conflict areas—seek to improve the safety of all road users at particular points within the urban transportation network. Photographs of the three devices can be seen in Figure 1.

![Figure 1](image)

Figure 1. From left to right, a bike-and-chevron style sharrow, a sharrow affixed to an outside lane, a “Bicycles May Use Full Lane” sign, and a colored bicycle lane at a conflict area.

SHARED LANE MARKINGS, SIGNS, AND COLORED LANES

A Shared Lane Marking, or sharrow, is a pavement marking that is affixed to the surface of the full lane that bicyclists are most likely to utilize; bicyclists are encouraged to ride at the lateral position within the lane indicated by the marking. The 2009 edition of the Manual on Uniform Traffic Control Devices (MUTCD) recommends that bike-and-chevron Shared Lane Markings be used to guide bicyclists to a safe position within the lane, alert motorists to the potential presence of bicyclists, encourage safe passing by motorists, and reduce the incidence of wrong-way bicycling. The only MUTCD standard for this device states that sharrows shall not be placed on shoulders or in bicycle lanes. When on-street parking is present, MUTCD guidance states that the center of each marking should be at least 11 feet from the curb face (or edge of pavement if no curb exists). For facilities without on-street parking, each marking should be placed at least 4 feet from the curb face or edge of pavement. It should be noted that Shared Lane Markings placed in the center of the usable lane meet both of these minimum requirements. The guidance further states that Shared Lane Markings should be reserved for roadways with a speed limit no greater than 35 mph, placed immediately after an intersection, and spaced no more than 250 feet apart (4).

The sharrow design used in this experiment was recommended by the National Committee on Uniform Traffic Control Devices’ (NCUTCD) Bicycle Technical Committee in 2007 (when the device was still classified as experimental) and is unmistakably similar to the Shared Lane Marking described in the 2009 MUTCD (5).
Another tool that addresses the same issue is the “Bicycles May Use Full Lane” sign. This paper examines the effectiveness of a regulatory-style, text-only sign (shown in Figure 1), which was chosen by the City of Austin for study. These signs can be placed along narrow facilities as a reminder of existing regulation—that bicyclists may legally share the full lane with motorists, that bicyclists can utilize the full lane instead of the sidewalk, and that motorists should be aware of the potential presence of bicyclists on urban streets (4). The MUTCD recommends a similar sign, R4-11, be used at locations where bicyclists cannot share the lane side-by-side with motorists and where bicyclists are likely to utilize the full lane. The recommended sign features a bicycle icon placed above the words “May Use Full Lane”. It is acceptable to use the sign to supplement Shared Lane Markings, but the two devices were examined separately in this study (4).

In addition to the safety concerns when sharing the full lane, bicyclists are also confronted with unsafe circumstances when utilizing bicycle lanes that intersect motor vehicle lanes. Points of conflict are most common where a right-turn-only lane crosses a bicycle lane that runs parallel to traffic and where a bicycle lane crosses a highway entrance or exit ramp at a more perpendicular angle. Traditionally, the bicycle lane is dashed along the section where motorists are expected to cross the bicycle lane. In order to improve the visibility of bicyclists and the awareness of motorists when crossing the conflict area, chartreuse thermoplastic was applied inside the bicycle lane throughout the dashed portion. The MUTCD does not define any standards or guidance for the use of color within bicycle lanes, however, the NCUTCD has approved similar use of color within bicycle lanes (6) and fluorescent yellow-green color used is designated for use in bicycle and pedestrian warnings (4). In this study, chartreuse, a color similar to yellow-green was chosen for the colored thermoplastic markings.

The study undertaken here compared before- and after-implementation data taken from a diverse set of bicycle facilities in Austin, Texas in order to determine the operational and safety implications of these three devices.

**PREVIOUS STUDIES**

A 1999 Shared Lane Markings study conducted in Gainesville, Florida found a significant increase in bicyclists riding in the street with traffic, a small but significant increase in bicycle-to-curb distance (3 in), and no change the space provided by passing motorists when sharrows were installed 3.5 feet from the curb on a 15-foot wide outside lane (7). San Francisco studied two different Shared Lane Marking designs along roadways with on-street parking, finding the bike-and-chevron to be most effective. The study found significant increases in bicyclist lateral position during passing and non-passing events, as well as a significant decrease in the proportion of bicyclists at risk of being struck by an opening car door. Also, motor vehicles increased their distance from parked vehicles by one foot during non-passing events when a marking was present. The chevron design also decreased sidewalk riding by 35% and wrong-way riding by 80% (8). The study described here differs from previous research by examining the effectiveness of Shared Lane Markings placed in the center of narrow motor-vehicle lanes where no on-street parking is permitted and by examining the effectiveness of sharrows placed to guide bicyclists between disconnected bicycle lane facilities.

Previous studies examining the effectiveness of “Bicycles May Use Full Lane” signs have not been conducted. The Bicycle Technical Committee of the NCUTCD recommended the sign for inclusion in the MUTCD in June 2005, since the sign makes motorists and bicyclists aware of accepted lane-sharing behavior on substandard lanes, where bicyclists and motorists cannot share the lane side-by-side (9).

Colored bicycle lanes have been studied in yielding areas St. Petersburg, Florida painted the pavement in a bicycle lane weaving area next to a right-turn only lane near an intersection, and installed “Yield to Bikes” signs with a diagram to guide motorists. A variable message sign and the local press were used to
spread awareness to the public about the project. The percentage of motorists who yielded to bicyclists was found to be significantly higher after the treatment was applied. One problem that arose was that some motorists misunderstood the solid green paint to mean that they should not cross, and would therefore cross behind or in front of the green weaving area (10).

Portland, Oregon experimented with blue bicycle lanes in areas where bicycles and vehicles come into conflict, such as an exit ramp, entrance ramp, and right turn lane. As in the sites studied in this paper, the Portland sites were previously defined with white dashed lines. The Portland study found significant increases in the percent of bicyclists following the path at the exit ramp location, and the percent of vehicles yielding to bicyclists at the exit ramp and right-turn turn locations. Bicyclists turned their head to check for traffic or used hand signals less frequently, leading to worries that the treatment lulled them into a false sense of security. Survey results showed that 75% of bicyclists and 49% of motorists felt safer after the installation, and 58% of bicyclists said drivers yielded more often (11).

EXPERIMENTAL DESIGN AND METHODOLOGY

After considering input from the local bicycling community, several City organizations, and the general public, Shared Lane Markings and “Bikes May Use Full Lane” signs were installed along five unique multi-lane facilities in Austin, Texas. The sharrow sites included a four-lane, one way street in downtown Austin (Guadalupe Street), a four-lane, two way arterial in suburban north Austin (51st Street), and a four-lane, two way arterial near The University of Texas campus (Dean Keeton Street). The sign sites included a four-lane, two way commuter route in south Austin and a four-lane route (Lamar Boulevard), and a two way non-commuter route in east Austin (Pleasant Valley Road). All sites had a posted speed limit of either 30 or 35 mph and typical peak traffic volumes between 200 and 400 vehicles per hour per lane (vphpl). All five facilities were designated as ‘low ease of use’ for bicyclists by the City of Austin due to a combination of high traffic volume, narrow outside lanes, and difficult connections.

Colored bicycle lanes were installed along two unique multi-lane facilities near The University of Texas campus. Three colored lane segments were installed on Dean Keeton Street where the bicycle lane crosses 1-35 exit and entrance ramps. A single colored lane segment was also installed on San Jacinto Boulevard near Duval Street where a right-turn bay crosses over a bicycle lane that runs parallel to the motor vehicle lanes. Both facilities had posted speed limits of 35 mph and traffic volumes between 150 and 300 vphpl.

In order to measure bicyclist and motorist behavior, video footage of traffic movements at each site was collected by a traffic monitoring camera mounted above an intersection along the studied facility. Video was recorded on weekdays between May 2009 and March 2010 during the traditional morning peak (6:00 AM to 10:00 AM) and afternoon peak periods (4:00 PM and 7:00 PM), except for the study sites near The University of Texas campus, where video was recorded during the morning peak period and between 2:00 PM and 5:00 PM, when traffic departing the university seemed to be highest. Video footage was played back on a flat panel monitor for analysis and a transparency placed over the screen allowed measurements of bicyclist and motorist lateral position to be recorded at a resolution of one-tenth of a lane width.

In order to determine what effect, if any, the three devices have on bicyclist and motorist safety, before-and after-sharrow data sets for each site were compared to determine if safer conditions existed after the installation. To account for any learning effects, a minimum of two weeks was allowed between the installation of the device and the start of recording the after-installation data. On facilities where the bicyclist was expected to share the full lane (as was the case with sharrows and signs sites), safe bicyclist behavior was defined by three factors:

1. The bicyclist rode at a central, safe location within the lane
2. The bicyclist did not ride outside of the lane (on the sidewalk or in empty parking spaces)
3. The bicyclist did not ride alongside queues of stopped vehicles

Further, safe motorist behavior was defined by two factors:

1. Motorists did not encroach on adjacent lanes when passing
2. Motorists made complete lane changes when passing

On facilities where a bicycle lane crossed a motor vehicle lane (as was the case with colored lane sites), safe behavior was defined as:

1. The bicyclist used the bicycle lane to approach the conflict area
2. The bicyclist used the bicycle lane to negotiate the conflict area
3. The motorist yielded to the bicyclist when crossing the colored lane area, and
4. The motorist used a turn signal when crossing the conflict area

To measure safety as defined above, several elements of the environment, bicyclist behavior, and bicyclist-motorist interaction were recorded. Among the measurements taken, where applicable, were traffic volume, lateral position of motor vehicles and bicycles in the lane during passing and non-passing events, percent of motor vehicles that change lane to pass or encroached on an adjacent lane while passing, percent of bicyclists traveling with traffic (as opposed to against traffic or on sidewalks), and percent of bicyclists who bypassed a queue of stopped vehicles.

Tests of statistical significance were conducted to determine if there were any notable differences between the before and after data. All proportions and means were compared using a two-sided test of equality, where the null hypothesis was that no change occurred and the alternative hypothesis that behavior changed. Educational information was intentionally not distributed to the public so that the device’s impact could be measured without interference.

TERMINOLOGY

The following terms are used throughout the following sections to characterize specific actions of bicyclists and motorists. Each term’s meaning in the context of this report is described below.

Sharrows and Signs Terms

- Bicyclist Lateral Position (BLP) – BLP is a measure of the bicyclist’s position within the lane. Due to geometric differences, BLP was measured in a manner most consistent with each site’s unique configuration. For example, when no on-street parking was provided, BLP was measured as the lateral distance between the bicyclist’s front wheel and the curb. Where delineated on-street parking was provided, BLP was measured as the lateral distance between the bicyclist’s front wheel and the on-street parking space delineation markings. Where no parking space delineation markings existed, BLP was measured as the lateral distance between the bicyclist’s front wheel and the outside edge of the parked motor vehicle.

- Motorist Lateral Position (MLP) – MLP is defined as the distance between the motorist’s curb-side wheel and the appropriate measurement—curb, parking space delineation marking, or parked motor vehicle—as explained in the BLP definition.

- Avoidance Maneuver – An avoidance maneuver was recorded whenever a bicyclist rode outside of the motor vehicle lane (e.g. rode on the sidewalk or in empty on-street parking spaces).

- Passing Event – A passing event was recorded when a motorist who previously shared the lane with a bicyclist pulled around the bicyclist. The measurements of BLP and MLP were taken...
simultaneously at the instant the front edge of the bicycle drew even with the front edge of the passing motorist.

- Non-Passing Event – A non-passing event was recorded when a bicyclist rode past the traffic monitoring camera and a passing event did not take place.

- Encroachment – Encroachment was recorded when a passing motorist occupied two lanes while passing.

**Colored Lane Terms**

- Yielding Event - A yielding event occurred when a bicyclist and motorist both attempted to navigate the conflict area at the same time.

- Motorist Yielded to Bicyclist - If the motorist allowed the bicyclist to navigate the conflict area first during a yielding event, the yielding event was described as 'car yielded to bicyclist'. If the motorist accelerated to cut off the bicyclist while the bicyclist was in the conflict area or the bicyclist yielded to the car during a yielding event, the yielding event was not described as 'car yielded to bicyclist'.

- Motorist Used Turn Signal - If the motorist used a turn signal when crossing the conflict area during a yielding event, the yielding event was described as 'motorist uses turn signal'.

**SITE DESCRIPTIONS AND RESULTS**

The following section describes the facility configuration at each study site and notable results gathered. Approximately 1,400 observations were made along the sharrow sites, 750 at the “Bicycles May Use Full Lane” signed sites, and 1,000 observations at the colored bicycle lane sites. Data was collected between August 2009 and March 2010 during peak travel hours for the site. Data was not collected within two weeks of a new treatment installation to allow road users to adjust to the new device.

**Shared Lane Markings (Sharrows)**

Between W 20th Street and W Cesar Chavez Street, Guadalupe Street is a four lane, one-way southbound street that extends from the southern edge of The University of Texas campus to the southern edge of downtown Austin. As shown in Figure 4, the travel lanes are 11 feet wide. The blocks along Guadalupe Street were approximately 370 feet long and sharrows were installed 40 feet after each intersection in the center of both the rightmost and leftmost vehicle lanes, since bicyclists on one-way streets may utilize either of those two lanes for through travel, resulting in a sharrow spacing of 370 feet. One unique feature of the this site is that on-street parking is provided along both sides of the facility. During peak commuting hours when the data was collected, the parking spaces were rarely full, allowing bicyclists to freely ride in the empty on-street parking spaces.
Figure 2 compares the distribution of BLP during non-passing events on Guadalupe Street before and after sharrow installation. After the sharrows were installed, the average BLP increased by 4.4 inches from 3.14 feet to 3.51 feet. More importantly, the mode of all observations increased from 1.1 feet to 5.5 feet, which is the location of the center of the sharrow. Figure 3 shows that the percentage of bicyclists riding in the center of the lane—defined as BLP between 4.4 and 6.6 feet—increased significantly from 31% to 42% after the installation of the sharrows. A significant change in BLP during passing events was not observed at this site, although passing events were significantly more rare after the sharrows were installed (p<0.01). It was hypothesized that passing events became less frequent because motorists were less likely to utilize the lane containing the markings and were therefore less likely to encounter a bicyclist in such a way that a passing event could occur. A comparison in the proportion of motorists utilizing the sharrow lane versus the lane immediately adjacent to the sharrow lane showed that motorists lane preference did not significantly change after the addition of the sharrows (p=0.82).

Figure 3 shows the changes in other safety measures that suggest sharrows had a significant influence on bicyclist safety on Guadalupe Street. Bicyclists were significantly less likely to make an avoidance maneuver after the implementation of the sharrow and motorists were more likely to change lanes while passing. An interesting comparison shows that while bicyclists were less likely to make an avoidance maneuver, they were more likely to bypass a queue of stopped vehicles after the sharrows were in place. This may suggest that the sharrow encouraged bicyclists to assert themselves more when sharing the roadway with motorists.
Figure 3. Notable bicyclist and motorist behaviors at the shared lane markings study sites
E 51st Street is a two-way, four-lane arterial that connects the suburban neighborhoods of north-central and north-east Austin. The facility has bicycle lanes west of Airport Boulevard and east of IH-35, but the lane width between Airport Boulevard and IH-35—a distance of about 2100 feet—narrows, forcing bicyclists and motorists to share the full lane. Along the narrow stretch of 51st Street, sharrows were placed at 250-feet spacing in the center of the outside lanes along both the east and west-bound directions of 51st Street, as illustrated in Figure 4.

In general, the safety improvements observed on E 51st Street were similar to those seen on Guadalupe Street. After the sharrows were installed, bicyclists tended to take a stronger position in the lane as evidenced by the increase in average BLP by 8 inches from 4.0 feet to 4.75 feet. The best indicator of safety improvement may be the increase in the mode of BLP observations from 3 feet to 5 feet. Figure 3 shows that the proportion of on-street bicyclists who rode in the center of the lane—defined as a BLP between 4 and 6 feet—increased from 44% to 54%. Additionally, bicyclists were no less likely to bypass a queue or make an avoidance maneuver after the installation of the sharrows. During the red signal phase, bicyclists would often leave the full lane to ride around the long queue of vehicles that was ahead of them. This may suggest that bicyclists on E 51st Street choose to ride on the sidewalk or ride around a queue of stopped vehicles for convenience, not for perceived lack of safety. The presence of the Shared Lane Marking did lead to a significant decrease—from 12% to 4%—of bicyclists riding against traffic on the sidewalk.

Dean Keeton Street is an east-west arterial that runs along the north side of The University of Texas at Austin campus. In Summer 2009, bicycle lanes were installed on the segment of Dean Keeton Street east of San Jacinto Boulevard as well as where space permitted on segments of Dean Keeton Street west of San Jacinto Boulevard. Where space did not permit the installation of bicycle lanes in accordance with City of Austin standards, sharrows were installed in August 2009. The following results compare operations on a section without bicycle lanes (but with upstream and downstream bicycle lanes) to data collected after the same section was provided with sharrows.
Figure 4. From top to bottom, the lane geometry and sharrow placement for the study sites on Guadalupe Street, 51st Street, and Dean Keeton Street.

Data was collected from a vantage point above the west leg of the intersection of Dean Keeton Street and San Jacinto Boulevard, where two sharrows were placed along a 380-feet gap in the bicycle lane. Bicyclists were recorded traveling westbound just after departing the intersection. Since the outside lane on the studied segment of Dean Keeton Street was wide enough to allow bicyclists and motorists to safely operate side-by-side, sharrows were not installed in the center of the lane, but rather off to one side. In accordance with MUTCD standards, sharrows were centered 11 feet from the curb, leaving 11 feet...
between the sharrow’s center and the next full lane. This positioning was chosen because bicyclists riding on the sharrow would be outside the parked vehicle door zone (measured as 3.42 feet) and still allow motorists to pass at a safe distance. Unlike the site at Guadalupe Street, the parking spaces on Dean Keeton Street were always filled such that cyclists could not ride in empty parking stalls. Figure 4 shows the studied segment of Dean Keeton Street near San Jacinto Boulevard.

After the sharrow installation, bicyclists tended to behave more predictably. Before the sharrows were installed, BLP during passing events was distributed evenly between 1.5 feet and 4.5 feet, while after the installation, nearly 70% of bicyclists rode 3 feet from the parked vehicles. While the decrease in standard deviation of BLP during passing events is notable, tests show that the change is not statistically significant (p=0.363). A similar but less pronounced trend was also observed for non-passing events—the distribution of bicyclist lateral position tightened around a mode of 4.5 feet. The marginal shift in average lateral position contributed to a large, significant decrease in the proportion of bicyclists who rode within the range of an opening car door.

As illustrated in Figure 3, instances of bicyclist avoidance and motorist encroachment decreased substantially after the sharrows were installed. This change, coupled with the increased predictability of bicyclist position during passing events, suggests that motorists feel more comfortable passing bicyclists without changing lanes when the sharrow is present and are therefore less likely to encroach on the adjacent lane when passing.

“Bicycles May Use Full Lane” Signs

“Bicycles May Use Full Lane” signs were installed along two multi-lane facilities: on the northbound side of South Lamar Boulevard, a facility that connects southern Austin to downtown, and on Pleasant Valley Road near Cesar Chavez Street, a facility that connects east Austin neighborhoods to parks and bike trails. The difference in bicycling population types at these two sites had a profound influence on the effectiveness of the signs on bicyclist and motorist behavior.

After the installation of the signs, bicyclists on Lamar Boulevard (a four-lane, two-way route with 11-feet lanes) tended to ride closer toward the center of the lane; during passing events the average BLP increased significantly from 2.42 to 2.73 feet from the edge of the curb (p<0.001) and the BLP during non-passing events increased from 2.83 to 3.03 feet (p=0.184). Although the increases in BLP were marginal, motorist position during incomplete passing events (where the motorist did not completely change lanes to pass) increased dramatically, resulting in significantly more space provided during incomplete passing events—from 3.69 to 5.34 feet on average, as depicted in Figure 6.
This increase in MLP also resulted in a significantly higher rate of encroachment, as shown in Figure 6. It should be noted that encroachment is only unsafe when another motorist occupies the adjacent lane—a variable that was not recorded in this study. Similar to some of the sharrow study sites, the signs on Lamar Boulevard were ineffective at decreasing instances of sidewalk riding, suggesting that both signs and sharrows are effective at improving the safety of bicyclists already utilizing the full lane.

The data collected from Pleasant Valley Road (a four-lane, two-way facility with 11-feet travel lanes) shows that signs may not be effective at universally improving bicyclist or motorist behavior. The proportion of bicyclists using the full lane decreased substantially after signs were installed near Cesar Chavez Street and Pleasant Valley Road. The proportion of bicyclists who rode on the sidewalk increased greatly, as did the proportion of bicyclists who made an avoidance maneuver (like cutting across a driveway near an intersection). Several issues emerged from site conditions at Cesar Chavez Street and Pleasant Valley Road that may have had an effect on the study results. Researchers observed that recreational sidewalk bicycling was a common occurrence at this intersection. This may have resulted in recording the same bicyclist multiple times in an observation period and overestimating the proportion of bicyclist riding on the sidewalk. It is difficult to avoid multiple counts of recreational sidewalk riders, since the resolution of the video camera being used did not allow bicyclists to be individually identified.

The combination of multiple driveways, a sidewalk connecting to an nearby extensive park trail system, long queues of cars at the intersection, and the lack of a shoulder or bicycle lane meant very few bicyclists were observed riding in the vehicle lane. Therefore there was insufficient data to effectively compare before and after bicyclist lateral position. For the same reasons, insufficient data was available to evaluate behavior during passing events. Before signs were installed, only 5.5% of all events were passing events. After signs were installed, passing events were observed less than 2% of the time.
Figure 6. Notable bicyclist and motorist behaviors at the "Bicycles May Use Full Lane" study sites

Colored Bicycle Lanes at Conflict Areas

Colored bicycle lanes and accompanying “Yield to Bikes” signs were installed on two multi-lane facilities in Austin. Maps of the two study sites are illustrated in Figure 7. Both facilities had existing bicycle lanes that were dashed through the conflict area and both study sites were located along popular commuting routes between The University of Texas campus and nearby neighborhoods. Three conflict areas were colored and special yield signs were installed on Dean Keeton Street, but data was only collected from the colored lane segment indicated in Figure 7 by a thick circle.
Figure 7. Diagrams of the bicycle lane conflict areas and signs on Dean Keeton Street (above) and San Jacinto Boulevard (below).

The channelization of motorist traffic across the colored lane on Dean Keeton Street left no option for motorists as where to cross the bicycle lane, while the San Jacinto application left motorists with a
The results described below lend credence to the hypothesis that the geometric configuration of a conflict area greatly influences effectiveness of a colored lane and sign treatment.

Figure 8. Notable bicyclist and motorist behaviors at the two colored lane study sites. *Note: P-values with an asterisk (*) did not meet the traditional rule of thumb for a two proportion test of significance.*

The data from the conflict area on Dean Keeton Street was acquired while classes were in session at The University of Texas between October 2009 and January 2010. As shown in Figure 8, bicyclists on Dean Keeton Street behaved very predictably—over 96% of bicyclists used the bicycle lane to approach and negotiate the conflict area before the colored lane was installed. Also before the treatment was applied, motorists did not exhibit the same predictability when confronted with bicyclists at the conflict area, as...
indicated by the inconsistent use of turn signals and yielding behavior when crossing the colored section. After the application of the colored lane and accompanying sign, turn signal use increased by 24% and motorists were 95% more likely to yield the right of way to oncoming bicyclists. These results suggest that colored lanes can have a significantly positive effect on the motorist behaviors that directly contribute to bicyclist safety.

Data from the conflict area on San Jacinto Boulevard was acquired while classes were in session at The University of Texas between August 2009 and April 2010. Relative to Dean Keeton Street, bicyclists riding on San Jacinto Boulevard were less likely to utilize the bicycle lane to approach and negotiate the conflict area. The addition of the colored lane treatment significantly influenced bicyclists to stay in the bicycle lane while approaching and negotiating the conflict area. This suggests that the addition of a colored lane can encourage more predictable bicyclist behavior even before one reaches a conflict area. Regarding motorist behavior, this study observed a slight increase in turn signal use, but motorists were 47% less likely to yield to bicyclists after the treatment. It may seem contradictory that turn signal use would increase while instances of motorists yielding decreased. However, this supports the hypothesis that while motorists are aware of the potential conflicts with bicyclists, they are unsure of how to cross the bicycle lane once the color was installed. After the color treatment, motorists would not yield to bicyclists by crossing the bicycle lane beyond the colored section.

**CONCLUSIONS AND RECOMMENDATIONS**

This study found that experimental bicycle safety devices—Shared Lane Markings, “Bicycles May Use Full Lane” signs, and colored bicycle lanes at conflict areas—can be effective at improving bicyclist and motorist safety while utilizing the urban bicycle network. When used as a standalone device or as a tool to guide bicyclists between facilities with bicycle lanes, Shared Lane Markings significantly improved the safety of bicyclists already utilizing the full lane by encouraging bicyclists to ride toward the center of the lane and encouraging safer passing behavior by motorists, but were not always effective at reducing unsafe bicyclist behavior like sidewalk riding or bypassing queues of stopped vehicles. It is recommended that sharrows be placed in the center of the usable lane unless motorists can safely operate side-by-side in the same lane (a lane width of 14 feet or greater).

“Bicycles May Use Full Lane” signs saw mixed results, likely due to differing bicyclist characteristics. Along a commuter route studied, safer behavior like more-central riding position for bicyclists and more space provided by passing motorists were observed. However, along one route that connected east Austin neighborhoods to a park and trail network, no improvements in safety were observed, particularly since sidewalk riding was so prevalent that little data could be collected about on-street bicycling behavior. So while there is a reasonable expectation that signs can be effective at improving the safety of bicyclists already utilizing the full lane, further research is needed to determine the exact effect of such signs on bicyclist and motorist behavior.

Coloring the dashed conflict areas on bicycle lanes proved most effective at our site where a freeway exit ramp crosses a bicycle lane. Motorists at that site were 34% more likely to yield to bicyclists and were more likely to use a turn signal when crossing the conflict area. At a site where motorists had to cross a parallel bicycle lane to access a right-turn bay, motorists were 42% more likely to utilize a turn signal, but much less likely to yield the right of way to bicyclists, instead opting to cross beyond the colored lane section. This confusion on the part of motorists might be alleviated with an education campaign.
REFERENCES


