Cyclist Behavior in Bicycle Priority Lanes, Bike Lanes in Commercial Areas and at Traffic Signals

A Master's Report Presented

by

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Executive Summary

Recent researches and surveys have shown that the number of bicycle trips have been increasing in a lot of US cities (1). To encourage more bicyclists, cities have designed and established exclusive bike lanes to separate bicyclists from other facilities. However, in some cities such as Boston, a lot of streets are too narrow to accommodate bicyclists and motorists side by side. To address the competition and negotiation between motorists and bicyclists, a shared lane (Sharrow) and Dutch suggestion lanes (Advisory Lane) are introduced and applied in some US cities. In Brookline, MA, a shared bike lane called Bicycle Priority Lane was developed since 2009. A critical feature of Bicycle Priority Lane is the longitudinal lane marking that delineates a bicycle zone as a lane-within-a-lane (2). Brookline has recently applied it on two 2-lane roads by using dotted white lanes to indicate the priority zone; the City of Boston plans to apply it on a 4-lane road in Allston next year as well.

The primary objective of this study is to study bicyclist’s behavior on Bicycle Priority Lane to determine if the marking changed bicycle position with respect to the door zone. In this research, data was collected in peak hours at three different streets which has or plans to have Bicycle Priority Lane. Those data are also used to compare with older data collected at different time by previous researchers. As a result, bicyclist position was found moved further away from right side hazards after the Priority Bicycle Lane was marked. The distance between bicyclist position and dominant parked car increased about 8 inches overall, and by about 7 inches when a bicyclists was influenced by a passing car. More bicycles are shown riding more than 3.5 feet away from the dominant parked cars, the overall rate increased about 14%, the rate for bicyclists influenced by passing cars increased about 18%. As the result of comparison between two roads with different design, when the priority lane is marked on the wider road section, bicyclist position will be further away from the right side hazards.

For those bicyclists who arrived at an intersection on red, the study shows that about 63% of them are compliant to the red lights. For those bicyclists who have a chance to safely violate the red due to a traffic break in the conflicting traffic, about 53% actually violated. Furthermore, the research result also shows that about 73% bicyclists stopped only after the rear wheel was in or in front of the crosswalk.

When an exclusive bike lane exists in a commercial area, the study found 47% bicyclists have moved out the bike lane during going through the commercial section, the main reasons include double parking, commercial unloading, parking maneuvering, bus pull in and pull out, and dooring.
Cyclist Behavior in Bicycle Priority Lanes

Background

Since 2009, “Sharrows” (Shared Lane Arrows or Shared Lane Markings) have been recommended by the MUTCD (The Manual on Uniform Traffic Control Devices) for guiding bicyclists to operate in the right position when the roadway is too narrow to make a separate bike lane. According to MUTCD guidance, a Sharrow consists of a bicycle silhouette topped by a double chevron. In order to reduce the chance of a bicyclist colliding with the open door of a parked car, the center of a Sharrow should be placed at least 11 feet away from the curb when a parking lane is present. For streets without a parking lane, the center of a Sharrow should be placed at least 4 feet away from the curb. (3) (Figure 1)

![Figure 1 A Photograph of Shared Lane Arrow or “Sharrow”](image)

Without a bike lane on a shared street, cyclist wishing to stay out of the way of drivers often ride too close to parked cars and risk being struck by a suddenly opened car door. Several studies have been conducted to evaluate the impact of installing Sharrows on shared streets.
In 2004, San Francisco studied two types of Shared Lane Markings: bike-in-house and bike-and-chevron. In contrast to the lane without marking, the study found the bike-and-chevron marking had an effective improvement on motorist positioning and in reducing wrong-way riding. As a result of bike-and-chevron marking, the overall distance of cyclists distance from parked cars increased 4 inches. The chevron design also significantly reduced sidewalk ridings by 35% and wrong-way ridings by 80% (4).

In 2010, to study the effects of shared lane markings, Texas compared the pre- and post-implementation data collected at different sites in the City of Austin. As a result of shared lane marking, the study found the bicyclists generally rode further from the curb and closer toward the center of the lane. When passing a bicyclist, motorists were also found more likely to change lanes to pass and were less likely to encroach on the adjacent lane (5).

The small shift found in these studies still leaves many bikes riding in the door zone. They continue to accept some risk of “Dooring” because they feel the risk of being hit by a passing car. When a motor vehicle intends to overtake a bike, motorists and bicyclists have shown opposing interests over the boundary of “bicycling zone” (2). Bicyclists want the boundary to move left to keep further away from right side hazards and have more operating space for riding in more relaxed manner, but motorists want the boundary to move right to reduce the delay when overtaking a bike. This conflict sets up a negotiation between motorists and bicyclists each time a car overtakes a bike.

To reduce the stress involved in lane sharing, different shared lane treatment has been developed in Netherland and US.

Different from Sharrow, in Netherland, “Suggestion Lane” (also referred as Advisory Lane) is a standard treatment for roads too narrow to mark a bike lane. The Dutch Suggestion Lane uses broken white lines and sometimes colored red pavement to suggest bicyclists use it and also guide motorists to gently use it and yield to bikes when they encounter opposing direction traffic (Figure 2). Dutch Suggestion Lane is only marked on roads without a centerline. Since 1997, a large before-after study showed that overall crash rate has significantly decreased; the crash rate involving bicycles also has a small drop (2). Furthermore, a before-after behavior study also found that the percentage of motorists encroaching right side bike zone has been reduced when there bicyclists present, also the fraction of shifting left and encroaching opposite direction bike zone has a much more significant drop (2).
As an adaption of Dutch Suggestion Lane, a scheme named “Bicycle Priority Lane” has been developed by Northeastern University in fall, 2008. This treatment is based on the principle that a shared lane should be demarcated as “lane-within-a-lane” to minimize the stress of negotiating for space between bicyclists and motorists. On the traffic lanes marked with “Bicycle Priority Lane”, the bicycling zone was delineating by intermittent modules of dotted lines bracketing a Sharrow. The modules are 20 feet long and 80 feet apart, as shown in Figure 3. The dotted lines are 10 feet and 15 feet away from curb on a road with parking, and 1 feet and 6 feet away without parking. With this marking, a continuous priority bicycling zone presents, motorists are impressed to yield the space to bikes, but at the same time, they are free to use it when no bike is there. In April, 2010, a “Bicycle Priority Lane” was adopted on Longwood Avenue in Brookline, MA. In November, 2010, another “Bicycle Priority Lane” was marked on Washington St in Brookline, MA. On both streets, the centerline was shifted to put a regular bike lane on one side and a priority bike lane on the other side.
Site Descriptions

Longwood Avenue, Brookline

The section of Longwood Avenue with Bicycle Priority Lane is 0.4 mile long, going west from Kent Street to Harvard St. With one lane in each direction, Longwood Ave goes through a residential area with many single family homes and few apartment buildings on both sides. It connects Boston’s biggest medical area to Brookline’s commercial center. The daily traffic volume is 8,000 vehicles and approximately 700 bicycles, with the speed limit of 30 mph.

A regular bike lane was placed along the eastbound Lane of Longwood Ave. The westbound lane, which has the treated priority bike lane, is 19.8 feet wide with parking.
The dotted lines are at 10.33 feet and 15.25 feet away from the curb. (Measured to the center of line)

**Washington St, Brookline**

The section of Washington Street with Bicycle Priority Lane is 0.2 mile long, going east from School Street to Harvard St. Like Longwood Ave, Washington Street has a regular bike lane one side and a priority bike lane on the other side. This section of Washington consists of residential, school, commercial and institutional property. The daily traffic volume is about 4,000 vehicles and with a much lower number of bicycles than Longwood Ave. On eastbound of Washington, the treated priority bike lane is 18 feet wide with parking; the dotted lines are putted at 10.01 feet and 14.9 feet away from the curb.

Design of both Longwood Ave and Washington St with Bicycle Priority Lane are shown in the Figure 4.

![Figure 4](image-url)
As shown in Figure 4, when the shared lane is 18 feet wide as on Washington Street, parking, bicycle and car cannot be fit side by side. A narrow travel lane might encourage bikes to not feel that they’re blocking cars. However, with approximately 20 feet wide shared lane on Longwood Ave, all roadway users can be fit side by side if the cars are not wide. As shown in Figure 5, when cars are parked close to the curb, the shared lane is wide enough that a narrow car could pass a bicycle with a 7 feet distance from parked cars. Therefore, a research question is whether, with the 18 feet lane width on Washington Street, bikes ride further from the parking lane than they do on Longwood Avenue with its 19.8 feet wide shared lane.

Figure 5 Longwood Ave- Potential for Bike and Car Side by Side

**Research Methodology**

In order to measure and evaluate bicyclist behavior, on-site data collection was conducted during the morning or afternoon peak hours when the bicyclist volume in the Bicycle Priority Lane is the greatest of the day. On Longwood Ave, the data collection time was set from 4pm to 6pm on weekdays. On Washington Street, the data collection time was set from 8 AM to 9:30 AM on weekdays.

As the main objective of bike priority lane is to encourage bicyclists to ride further away from right side hazards such as door zone and curb, the most important measurements to evaluate bicyclist behavior is the riding position during both passing and no-passing
events. In this study, bicyclist position was measured visually using chalk lines drawn with 0.5 feet intervals, which allow bicycle wheel position be recorded in the range of 0.5 feet. In order to measure the influence of motorists and evaluate the level of stress of negotiating the space with motor vehicles, bicycles are defined as with or without the influence of a passing motor vehicle. Bicyclists were also categorized as male or female and with or without helmet. Also, to make sure data is collected accurately, several principles have been followed:

- Data collection points where 3 or more parking spaces were unoccupied were not used.
- Data collection points near a traffic light, stop sign or yield to pedestrian sign were not used.
- Parked Cars vary on the distance from curb. Bicycle position at any point is believed to be influenced by a dominant parked car, which is the one with the greatest reach from the curb near the bicyclist. To capture this effect with minimum distortion, data collection point is always at front wheel of a dominant parked car, or at the front wheel of the car parked just after it.
- Periods when a traffic queue came close to the data collection point were not used.
- Periods in which double parking or a parking maneuver happened near the data collection point were not used.
- Data collection person must stand at a place where his appearance will not influence bicyclist’s judgment or behavior. Also, the grid of chalk marks was not believed to influence behavior, since they were visible only a very short distance in advance (2).

On Longwood Avenue, earlier research conducted by Northeastern University made counts shortly after the Sharrow was marked. This data collected almost one year later was analyzed and compared to the previous Northeastern University results. As a result, we can see the trend over time on Longwood Ave. Furthermore, counts at Washington St were analyzed and compared to Longwood Ave counts as well. The influence by different designs will be studied.

**Analysis and Discussion**

**Longwood Ave, Brookline**

As shown in the previous Northeastern University research results, bicyclist behavior was getting statistically significant different after 4-5 weeks. In Northeastern research, 278 bicyclists were counted before the bracketed sharrow has been marked, 151 bikes has been counted 1-2 weeks later, 83 bikes were observed 5 weeks later, 138 bikes were observed 1 year after the bracketed sharrow has been marked. In this study, which the data has been collected about 1.5 years after the priority bike lane has been marked, 182 bicyclists’ behavior were observed in two weekdays.
Before-after comparison of bicycle position with respect to offset from curb.

As shown in Table 1, the mean offset from curb for both all observed bicycles and fractional bicycles influenced by passing car has been calculated. The fraction of bicycles with offset equal or more than 10.5 feet away from curb has also been calculated. As a result, 1 to 2 weeks later, bicyclist’s position was almost the same as before the bracketed Sharrow has been marked, but 5 weeks later, the position of bicyclist had a statistically significant difference, in which the mean offset from the curb increased about 0.8 feet for all bicycles and approximately 1 foot for bicycles influenced by passing car. For all bicycles, the percentage of bicyclist riding more than 10.5 feet away from the curb rose from 47% to 72% in 5 weeks. For bicycles influenced by passing car, the percentage of bicyclist riding more than 10.5 feet away from the curb also rose from 39% to 68% in 5 weeks. However, comparing data collected 1 year and 1.5 year later, the mean offset from curb has decreased again. The calculated mean offset from curb was almost the same as before the Priority Bicycle Lane was marked, as well as the fraction of bicycles with offset equal or more than 10.5 feet away from curb. As shown in Figure 6 and Figure 7, the average position of bicyclists influenced by passing cars rose from 0 to 0.3 feet closer to the right side hazards than the position of bicyclists without vehicles passing. For the fraction with offset equal or more than 10.5 feet, bicyclists without vehicles passing are 2% to 8% higher than bicyclists influenced by passing cars.

As bicyclist position was measured visually using chalk lines drawn with 0.5 feet intervals, the assumed bicyclist position was in the middle of the interval in which they were observed.

However, “offset from the curb” results is believed to inaccurately reflect the trend of bicyclist position. Bicycle position at any point is believed to be influenced by a dominant parked car. With data collected at different times and different points where the extension of dominant parked cars varied, bicyclist position with respect to the curb will be different.
<table>
<thead>
<tr>
<th>Time with respect to the marking of bracketed Sharrow</th>
<th>All Observed Bicycles</th>
<th>Observed Bicycles Influenced by Passing Car</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N of bikes observed</td>
<td>Overall mean offset from curb(ft)</td>
</tr>
<tr>
<td>before</td>
<td>278</td>
<td>10.55</td>
</tr>
<tr>
<td>1-2 weeks after</td>
<td>151</td>
<td>10.85</td>
</tr>
<tr>
<td>5 weeks after</td>
<td>83</td>
<td>11.35</td>
</tr>
<tr>
<td>1 year after</td>
<td>138</td>
<td>10.65</td>
</tr>
<tr>
<td>1.5 years after</td>
<td>182</td>
<td>10.55</td>
</tr>
</tbody>
</table>

Table 1 Before-after comparison of bicyclist position on Longwood Ave, Brookline

Figure 6 Before-after trend of mean offset from curb on Longwood Ave, Brookline
When bicyclists share space with motorists in a narrow traffic lane, bicyclists want to move left to keep further away from right side hazards such as parked cars and to have more operating space for riding in a more relaxed manner. It is believed that bicyclist will judge the level of safety by visually measuring the distance from dominant parked cars instead of the offset from curb. In this research, the mean offset from the “dominant parked cars” (the nearly parked car extending furthest from the curb) was also statistically compared. This was possible because data collection included measuring the distance from the curb to the left front wheel of the dominant parked car. The result is shown in Table 2. After the priority bike lane was marked, the average offset of bicyclist position from dominant parked cars increased from 3.65 feet to 4.45 feet in 2 weeks. Five weeks after the marking, the mean offset of bicyclists influenced by passing cars rose up from 3.45 feet to 4.45 feet. As of the latest data collection, the mean offset of all bicycles is 4.25 feet. The mean offset of bicyclists influenced by passing cars is 3.85 feet.

Figure 7 Before-after trend of fraction of bikes with offset from curb equal or more than 10.5 feet on Longwood Ave, Brookline

**Before-after comparison of bicycle position with respect to distance from dominant parked car**
As bicyclist position was recorded in 0.5 feet intervals, the actual bicyclist position should be assumed to vary uniformly within this interval. For example, if a bicycle passes the data collection point between the chalk lines marked with 9 feet and 9.5 feet, it will be recorded as 9 feet. In fact, for all of the bicyclists whose position was recorded as 9 feet, the real position was at some point between 9 feet and 9.5 feet. Using the middle point of two chalk lines, the average real distance increased approximately 0.25 feet.

<table>
<thead>
<tr>
<th>Time with respect to the marking of bracketed Sharrow</th>
<th>All bicycles</th>
<th>Bicycles influenced by passing car</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N of bikes observed</td>
<td>Mean offset from dominant parked car (ft)</td>
</tr>
<tr>
<td>before</td>
<td>278</td>
<td>3.65</td>
</tr>
<tr>
<td>1-2 weeks after</td>
<td>151</td>
<td>4.45</td>
</tr>
<tr>
<td>5 weeks after</td>
<td>83</td>
<td>4.35</td>
</tr>
<tr>
<td>1 year after</td>
<td>138</td>
<td>4.45</td>
</tr>
<tr>
<td>1.5 years after</td>
<td>182</td>
<td>4.25</td>
</tr>
</tbody>
</table>

Table 2 Before-after comparison of bicyclist position from parked cars on Longwood Ave, Brookline

While assuming a midpoint position is accurate when calculating mean offset between bikes and parked cars, it causes a distortion when calculating the fraction of bikes more than 3.5 feet from a parked car. As shown in Figure 8, when the dominant parking extends 6.75 feet (6'9"), bicyclist position with 3.5 offset is 10.25 feet away from the curb. For those bicyclists whose positions were recorded as 10 feet, some of them were actually riding more than 3.5 feet away from the dominant parked car, and some weren’t. To get a more accurate result, the following formula has been adopted in the calculation:

\[
p = \begin{cases} 
0 & \text{if } \text{nominal } y-x \leq 3 \\
1 & \text{if } \text{nominal } y-x \geq 3.5 \\
1 - \left\{ \frac{3.5-(y-x)}{0.5} \right\} & \text{if } 3.0 \leq y-x \leq 3.5 
\end{cases}
\]

in which,
\( \mathbf{x} \): the distance that the dominant parked car extends from the curb

\( \mathbf{y} \): the nominal distance from bicyclist position to the curb=start of the interval holding bicycle wheel

\( \mathbf{y-x} \): nominal difference between the nearest parked car position and bicyclist position

\( \mathbf{p} \): probability that bicycle offset from parked car \( \geq 3.5 \) feet

The offset from parked cars to bicyclists on Longwood Ave has been analyzed and summarized as shown in Table 3.

<table>
<thead>
<tr>
<th>Time with respect to the marking of bracketed Sharrow</th>
<th>All observed bikes</th>
<th>Bikes influenced by a passing car</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of bikes observed</td>
<td># of bikes with offset ( \geq 3.5 )</td>
</tr>
<tr>
<td>before</td>
<td>278</td>
<td>141</td>
</tr>
<tr>
<td>1-2 weeks after</td>
<td>151</td>
<td>86</td>
</tr>
<tr>
<td>5 weeks after</td>
<td>83</td>
<td>63</td>
</tr>
<tr>
<td>1 year after</td>
<td>138</td>
<td>92</td>
</tr>
<tr>
<td>1.5 years after</td>
<td>182</td>
<td>117</td>
</tr>
</tbody>
</table>

Table 3 Before-after comparison of bicyclist position from parked cars on Longwood Ave, Brookline

As a result, the fraction of bicycles with offset equal or more than 3.5 feet increased since the Priority Bicycle Lane has been marked. One and half years later, the fraction with offset more than 3.5 feet for all observed bikes rose from 51% to 64%, also rose from 42% to 57% for bicycles influenced by passing car.

Results based on distance from parked cars are also shown in Figure 9 and Figure 10.
Figure 8 Bicycle’s Real Position from Dominant Parked Car

Bicyclists with real position beyond 3.5 feet away from parked cars
Figure 9 Before-after trend of mean offset from parked cars on Longwood Ave, Brookline

Figure 10 Before-after trend of offset more than 3.5 feet away from parked cars on Longwood Ave, Brookline
**Washington St, Brookline**

Brookline’s second priority bicycle lane was marked on Washington St in November, 2010. Same as Longwood Ave, the bicycling zone was delineating by intermittent modules of dotted lines bracketing a Sharrow. Modules are 20 feet long and 80 feet apart, as shown in Figure 3. However, the shared lane on Washington St is too narrow to fit all traffic side by side. The treated priority bike lane reaches 18 feet from the curb, with a parking lane marked with a solid white line at 7 feet from the curb. The dotted lines of the bicycling zone are at 10 feet and 15 feet away from the curb.

During the data collection, observation time was set from 8 AM to 10 AM on weekdays. Because the number of bikes on Washington Street is much less than Longwood Ave, data was collected in 4 weekdays. In total, 50 bicyclists’ behavior was recorded.

In November, 2011, the data was collected one year after the Bracketed Sharrow was marked on Washington Street. As shown in Table 4, the mean offset from the was were compared to the Longwood Ave results when the Bicycle Priority Lane has been marked for 1 year.

<table>
<thead>
<tr>
<th>Street</th>
<th>Time with respect to the marking of bracketed Sharrow</th>
<th>All bicycles</th>
<th>Bicycles influenced by passing cars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N of bikes observed</td>
<td>Mean offset from Curb (ft)</td>
<td>% with offset ≥10.5 ft</td>
</tr>
<tr>
<td>Longwood Ave</td>
<td>1 year later</td>
<td>138</td>
<td>10.65</td>
</tr>
<tr>
<td>Washington St</td>
<td>1 year later</td>
<td>50</td>
<td>10.35</td>
</tr>
</tbody>
</table>

Table 4 Comparison of bicyclist position when the Bicycle Priority Lane has been marked for one year on Longwood Ave and Washington St, Brookline

As a result shown in Table 4, one year after the priority lane was marked, bicyclist position is further from the curb on Longwood Ave than on Washington Street. The overall mean offset from curb was 10.35 feet on Washington St, which is 0.3 feet smaller than Longwood Ave. For bikes influenced by passing cars, the mean offset from curb is also 0.5 feet smaller on Washington St. In addition, the fraction of bicyclist position with offset equal or more than 10.5 feet on Washington Street is 13% percent lower for all bikes and 23% lower for bikes with passing cars.
The distance from the dominant parked car to bicyclist position was also been calculated and compared. The results of Longwood Ave and Washington St are shown in Table 5:

<table>
<thead>
<tr>
<th>Street</th>
<th>Time with respect to the marking of bracketed Sharrow</th>
<th>All Observed Bicycles</th>
<th>Observed Bicycles Influenced by Passing Car</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N of bikes observed</td>
<td>Mean offset from dominant parked car (ft)</td>
<td>% with offset ≥ 3.5 ft</td>
</tr>
<tr>
<td>Longwood Ave</td>
<td>1 year after</td>
<td>138</td>
<td>4.45</td>
</tr>
<tr>
<td>Washington St</td>
<td>1 years after</td>
<td>49</td>
<td>3.22</td>
</tr>
</tbody>
</table>

Table 5 Comparison of bicyclist position from dominant parked cars when the Bicycle Priority Lane has been marked for one year on Longwood Ave and Washington St

As the table shows, on Washington St, bicyclist position is more than 1 feet closer to dominant parked car than on Longwood Ave. The percentage of bicyclists with offset equal or more than 3.5 feet was only 17% when influenced by passing car, while on Longwood Ave, the result was 63%.

On Washington Street, where motorists have less space to pass without crossing the centerline, it appears that cyclists stay further to the right in order to give the motorists more space. The data do not support the hypothesis that with a narrow shared lane, bicyclists will feel more comfortable about blocking traffic, and ride further from parked cars.
**Brighton Ave, Allston**

Different from Longwood Ave and Washington St, Bicycle Priority Lanes have not been marked on Brighton Ave yet. The purpose of this study is to study bicycle position without bicycling zone on the street, so that after the Sharrow is marked bicyclist position can be measured analyzed again to make a comparison.

Brighton Ave is a four lane two-way road with parking lane on each side. According to the city’s bicycle improvement plan, a bicycle priority lane will be marked in each direction in 2012. The section of Brighton Ave located in Allston is a major road that connects Boston to Brighton. The daily traffic volume is about 30,000 vehicles and the number of bikes per day is approximately 800. The speed limit is 30 mph. In each direction, the outside traffic lane is 11.1 feet, the inside traffic lane is 12.3 feet wide, with parking lane as wide as 8.8 feet on the right. In the middle of road, there is a raised median.

The Same measurement used on Longwood Ave was used on Brighton Ave, all the principles have been followed as well. The data collection time Eastbound was set from 8 AM to 10 AM on weekdays. Westbound was set from 4 PM to 6 PM on weekdays, when the traffic volumes and bicyclists’ volume were the greatest of the day. Because Brighton Avenue has two lanes in each direction, cars who passed bikes using the inside lane was not assumed to influence bicyclist position. A bicyclist was influenced by a passing car if cars were driving in the outside lane directly behind a bicycle, and while cars that had been using the outside lane passed a bike (not counting those who switched to the inside lane long before reaching the bike).

Since the priority bicycle priority lane on Brighton Ave hasn't been marked yet, the data collected in this research will be classified as “before”. Bicyclist position will be researched with respect to the distance from the curb and distance from the dominant parked car. The analysis results are compared to the results of Longwood Ave before the Priority bike lane was marked. As show in Table 6 and Table 7:
Table 6 Comparison of mean offset from curb for bicycles on Brighton Ave and Longwood Ave before the Sharrow is marked

On Brighton Ave, the overall mean offset from curb is 0.4 feet lower than the offset was on Longwood Ave. When influenced by passing car, the bicyclist position from curb gets 0.5 feet closer to the curb, making it 0.7 feet lower than the offset on Longwood Ave. In addition, the fraction of bicyclist position with offset equal or more than 10.5 feet is 25% for all bicycles and 13% when influenced by passing car. Compare to Longwood Ave without Sharrow, the fraction is more than 20% lower.

Bicyclist position with respect to the distance from the dominant parked car is also compared to the Longwood Ave before data. Results are shown in Table 6:

<table>
<thead>
<tr>
<th></th>
<th>All bicycles</th>
<th>Bicycles influenced by passing cars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N of bikes observed</td>
<td>Mean offset from Curb (ft)</td>
</tr>
<tr>
<td>Longwood Ave Before</td>
<td>278</td>
<td>10.3</td>
</tr>
<tr>
<td>Brighton Ave Before</td>
<td>212</td>
<td>9.9</td>
</tr>
</tbody>
</table>

Table 7 Comparison of mean offset from dominant parked car for bicycles on Brighton Ave and Longwood Ave before the Sharrow is marked

<table>
<thead>
<tr>
<th></th>
<th>All Observed Bicycles</th>
<th>Observed Bicycles Influenced by Passing Car</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N of bikes observed</td>
<td>Mean offset from dominant parked car (ft)</td>
</tr>
<tr>
<td>Longwood Ave Before</td>
<td>278</td>
<td>3.65</td>
</tr>
<tr>
<td>Brighton Ave Before</td>
<td>212</td>
<td>3.71</td>
</tr>
</tbody>
</table>
On Brighton Ave, when there is no passing car, more than 63% of bicyclists are riding with offset more than 3.5 feet from the dominant parked cars, the mean offset was about 3.46 feet. The result also shows the big influence of passing car. When a passing car was present, the mean offset of bicyclist position reduced approximately 0.45 feet. The fraction of bicycles with offset more than 3.5 feet also reduced from 63% to 43%. Compare to bicyclist position on Longwood Ave before the Sharrow was marked, more bicyclists are willing to ride 3.5 feet away from the parked cars. One reason for this difference was the lower frequency of bicyclists influenced by passing cars. When there was a passing car, there was almost no difference between Brighton Ave and Longwood Ave.

**Conclusion**

By analyzing collected data and compare it to the older data, the study observed that after the installation of Bicycle Priority Lane on Longwood Ave, bicyclists generally rode further away from the curb. The distance between bicycle and dominant parked car also has a significant increase, which means bicycles position moved towards the center of the road. This implied that cyclists riding on a bicycle priority lane feel less stress from motorists. According to the analysis result, the position of bicyclists influenced by passing cars moved a little back to right side after 1.5 years compared to after 1.0 years. But after the Bicycle Priority Lane has been marked, the position of bicyclists influence by passing cars moved further away from right side hazards.

As a result of studying bicycle position on different street, when a bicycle priority lane has been adopted in a narrower travel lane, where motorists have less space to pass through without crossing the centerline, it appears that cyclists stay further to the right in order to give the motorists more space.

The Lane-Within-A-Lane treatment looks like it is effective in bringing a shift in bicyclists’ position further away from right side hazards. On Longwood Ave has an effective improvement after the priority lane has been marked. It is expected to see this treatment be effective on Brighton Ave in next year.
Bicyclist Behavior at Red Lights

Crossing a signalized intersection against red lights is believed to be one of the most dangerous and illegal behaviors for motorists, also it has been legally prohibited to bicyclists and pedestrians. However, different from motorists, one can easily see pedestrians and bicyclists going through red lights every day. People often make a fuss about “what if bikes went through red lights.” Actually, many bicyclists go through red lights already.

Different cyclists have different waiting and queuing behaviors at the red lights. The same bicyclist also will perform differently when approaching different roads.

The purpose of this research is to establish the rate of bicyclists riding through red lights. Two major factors, waiting behavior and queuing behavior, will be observed at different locations.

Define sets of behaviors

Several researches about pedestrian behaviors at signal intersections have been published, but not much about bicyclist behavior. In those pedestrian studies, a set of behavior has been defined, including: waiting location and behavior, looking behavior, pace, route choice, etc. In this study, two sets of bicyclists’ behavior have been defined as well: waiting for green behavior, and behaviors with respect to queuing.

Waiting for green

Before the sets of waiting behaviors have been defined, several on-site observations have been completed. As discovered in the observations, bicyclists’ behaviors for waiting for green are various. Some bikes may not go until the lights turn green. Some may ignore the red lights, Some may go through red lights only when there is a large gap in conflicting traffic. As a result, bicyclists waiting behaviors has been defined as:

- Waiting for green (W-green): means bikes going through only after the light have changed to green
- Don't Wait (don't -W): means bikes going through a red light against red lights, never stop or wait for green
• Waiting for Break (W-break): means bikes wait till they can go without interfering with other traffic, when there is a traffic break in the conflicting direction
• Push you way through (Push-thrg): means bikes wait till they can go, but they interfere with other traffic, and force other traffic to stop or yield for bicyclists
• Waiting for conflicting yellow (W-Con Yellow): as the author observed at different locations, some bicyclists leave the stop line when the lights on the conflicting direction turn yellow, though is still red for the bicyclist

Queue Position with Respect to First Stopped Car

When cars approach at signalized intersection, they often queue in line with each other according to arriving time. But bikes are different; they are much smaller and easier to move. Instead of queuing in the line with stopped cars, they can stop at any location where they feel comfortable. As shown in Figure 11, this research has recorded bicyclists’ queuing behavior according to following definitions:

• Queuing even with the first stopped car (Q-even): means bikes stopping with their front behind the front of the first stopped car
• Queuing partially advanced (Q-partially adv): means bikes stop beside the first stopped car and partially on front of it
• Queuing fully advanced (Q-fully adv): means bikes with their rear wheel ahead of the first car’s front bumper, either in an extension of the bike lane or in front of the first stopped car
• Queuing on the sidewalk (Q-sidewalk): means bikes son the pedestrian sidewalk

Because this research observed only locations with bike lane and/or parking lanes, bicycles never queued in line with motor vehicles.
Figure 11 Bicyclist Queue Position with Respect to First Stopped Car
**Waiting Position with Respect to the Stop Line and Crosswalk**

Cars are required to stopped before the stop line, so enough and comfort space will be left for pedestrians and traffic in conflicting directions. In Massachusetts, stop lines usually extend across bike lanes. However, bikes often stop at different positions from the vehicle stop line. As shown in Figure 12, this study has also defined a set of bicycles’ stopping positions. The definitions included:

- Waiting behind the stop line (W-behind-SL): means bicyclists who stopped before the front wheel crosses the stop line
- Waiting beyond stop line (W-beyond-SL): means bikes are stopped partly or completely in front of the stop line, but the rear wheel hasn’t entered
- Waiting in Crosswalk (W-in-CW): means the bike’s rear wheel is in the crosswalk
- Waiting beyond of Crosswalk (W-beyond-CW): means both wheels of bike are in front of the crosswalk marking

At the observed intersections, Crosswalk markings are about four feet beyond the stop line.
Figure 12 Bicyclist Waiting Position with Respect to Stop Line and Crosswalk
In addition to those characters above, other characters such as the gender of bicyclists, with or without helmet, with or without traffic break on the conflicting directions, etc., were also observed.

_data_

All those data were collected on good weather weekdays during the months of October and November, 2011. Data were collected during the morning peak hours, as well as during peak hours in the afternoon. To ensure that the data were accurate, a video camera was used to capture the approaching bicyclists, the videos were also later reviewed multiple times to identify each of the identified recordable behaviors.

In order to observe bicyclists behavior in different riding environment, data was collected at three different sites, with different bike lane design, and different width of the conflicting road, including 2 lanes, 3 lanes and 6 lanes.

For each location, the data collection has been conducted for two times, one time is in from 8AM to 10AM; another time is from 4PM to 6PM. In this study, only bikes arriving on red were observed.

_study locations_

For this research, three intersections have been chosen for data collection. All three locations have bike lanes and a high bicycle volume. Three intersections include Longwood Avenue at St. Paul Street in Brookline, Massachusetts Avenue at Sidney Street in Cambridge, and BU Bridge at Commonwealth Avenue in Boston.

_Longwood Ave @ St. Paul St, Brookline_

Both Longwood Ave and St. Paul St are two lane roadways with parking lane on each side. Longwood goes through residential area with single families, apartments along the road. As mentioned in the first chapter of this report, Longwood Ave has a shared “Bicycle Priority Lane” westbound, and a regular bike lane eastbound. The daily traffic volume on Longwood is 8,000 vehicles and approximately 700 bicycles, with the speed limit of 30 mph. The data at Longwood Ave eas collected eastbound from 8 AM to 10 AM, westbound from 4 PM to 6 PM.
Massachusetts Ave @ Sidney St, Cambridge

Massachusetts Ave is a major thoroughfare in Boston and Cambridge. Near the study area, Massachusetts Avenue is running through college campuses and bustling commercial areas. The daily traffic volume is about 22,400 vehicles and with one of heaviest daily bike volume. Data was collected northbound in both from 8 AM to 10 AM and from 4 PM to 6 PM.

As shown in Figure 14, Massachusetts Ave has a bike lane on the right of travel lanes. Because it is a slightly offset intersection, in both directions the Mass Ave curb continues about 25 feet beyond crosswalk to the conflicting traffic lane. Dashed bike lanes are visible in this region. Originally, dashed lines went through intersection, but the part traversed by traffic has been worn out.

Sidney Street has 3 travel lanes east of Massachusetts Ave (what northbound bikes have to cross) and 2 travel lanes west of Massachusetts Ave.
BU Bridge at Commonwealth Avenue, Boston

To be more bicycling friendly and to leave room during construction, the BU Bridge had a reduction of travel lanes, 2 lanes has been reduced to one lane in each direction, and a 5 feet width bike lane has also been marked in each direction. It connects Cambridge to Boston and Brookline at Commonwealth Ave, which has three travel lanes in each direction and two way light rail in the middle of road. The data was collected from 4 PM to 6 PM for bicycles going off the bridge. A lot of students and other adults ride bikes through this intersection every day.

The intersection is about 150 feet wide crossing Commonwealth Ave. The curb at the stop line extends about 10 feet beyond the crosswalk to the first conflicting lane on Commonwealth Ave, which is a bike lane.
Analysis and Discussion

All the data collected at different locations through video recording has been viewed multiple times to make sure all the bikes behavior has been recorded correctly. The number of bicyclists with different waiting or queuing behavior has been counted and compared as shown in Table 5.

Waiting for Green

When bicyclists go through a signalized intersection on red, it is common to define as “Compliant” if the cyclist goes through the intersection only when the signal is green. In this research, bicyclists who arrive on Green were not observed. For the behavior of waiting for green, the fraction of compliant bicyclists was more than the fraction of non-compliant bicyclists because the fraction who waited for green was more than 50% at three selected locations. However, more bicyclists will choose to wait for green light when the road they are crossing is wider. About 58% bicyclists wait for green light when crossing St. Paul Street, while about 81% bicyclists will wait until light changes to green when crossing Commonwealth Avenue. Obviously, bikes from BU Bridge have to cross 6 travel lanes on Commonwealth Avenue, versus only two lanes for bicyclists on Longwood Avenue, non-compliant bicyclists will have more stress and risk when
crossing against the red. Only 60% percent bicyclists on Mass Ave at Sidney St wait for green light, which is almost the same as those on Longwood at St. Paul. If bicyclists go across an intersection when the light is not green, most of them will go when there is a traffic break. The highest percentage is observed at Mass Ave on Sidney Street, which is 28%.

<table>
<thead>
<tr>
<th>Type of Behavior</th>
<th>Longwood @ St. Paul</th>
<th>Mass Ave @ Sidney</th>
<th>BU Bridge @ Common Ave</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waiting For Green</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W-green</td>
<td>23 (60%)</td>
<td>22 (58%)</td>
<td>25 (81%)</td>
<td>78 (63%)</td>
</tr>
<tr>
<td>Don't-W</td>
<td>3 (9%)</td>
<td>3 (9%)</td>
<td>1 (3%)</td>
<td>8 (7%)</td>
</tr>
<tr>
<td>W-break</td>
<td>7 (19%)</td>
<td>10 (28%)</td>
<td>4 (13%)</td>
<td>23 (20%)</td>
</tr>
<tr>
<td>Push-thrg</td>
<td>0 (0%)</td>
<td>1 (3%)</td>
<td>0 (0%)</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>W-Con Yellow</td>
<td>5 (14%)</td>
<td>1 (3%)</td>
<td>1 (3%)</td>
<td>9 (8%)</td>
</tr>
<tr>
<td>Queuing Behavior</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q-even</td>
<td>2 (5%)</td>
<td>1 (3%)</td>
<td>0 (0%)</td>
<td>3 (3%)</td>
</tr>
<tr>
<td>Q-partially adv</td>
<td>11 (30%)</td>
<td>4 (11%)</td>
<td>6 (19%)</td>
<td>23 (19%)</td>
</tr>
<tr>
<td>Q-fully adv</td>
<td>23 (62%)</td>
<td>32 (84%)</td>
<td>23 (74%)</td>
<td>85 (71%)</td>
</tr>
<tr>
<td>Q-Sidewalk</td>
<td>1 (3%)</td>
<td>1 (3%)</td>
<td>2 (6%)</td>
<td>8 (7%)</td>
</tr>
<tr>
<td>Waiting Position</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W-behind-SL</td>
<td>2 (6%)</td>
<td>1 (3%)</td>
<td>4 (13%)</td>
<td>7 (7%)</td>
</tr>
<tr>
<td>W-beyond-SL</td>
<td>12 (34%)</td>
<td>4 (11%)</td>
<td>4 (13%)</td>
<td>21 (20%)</td>
</tr>
<tr>
<td>W-in-CW</td>
<td>21 (60%)</td>
<td>7 (19%)</td>
<td>14 (45%)</td>
<td>42 (40%)</td>
</tr>
<tr>
<td>W-beyond-CW</td>
<td>0 (0%)</td>
<td>25 (68%)</td>
<td>9 (29%)</td>
<td>34 (33%)</td>
</tr>
</tbody>
</table>

Table 5 Bicyclists Behavior at Red Lights Comparison

However, the conflicting traffic volume at those 3 locations is different, so the chance for bicyclists to get a traffic break varied. For example, if a bicyclist arrives on red at Mass Ave, he may have a policy of crossing on red if there is a traffic break, but if he arrives on Green he will not have the opportunity to violate the red light. To more accurately evaluate bicyclists’ behavior at different locations, when viewing videos, the opportunity of a traffic break was recorded. The analysis in Table 6 include only bicycles who arrived on red and saw a break in conflicting traffic while the light was still red. As a result, bicyclists at BU Bridge have the smallest “violation policy rate” at 43%, while Longwood Ave at St. Paul St is 11% higher at 54% and Mass Ave at Sidney St has 20%
Higher at 63%. Policy violation is actually higher if bicyclists who go on conflicting yellow are counted.

<table>
<thead>
<tr>
<th></th>
<th>Longwood Ave @ St. Paul St</th>
<th>Mass Ave @ Sidney St</th>
<th>BU Bridge @ Commonwealth Ave</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td># of bikes see a traffic break at red lights</td>
<td>13</td>
<td>16</td>
<td>14</td>
<td>43</td>
</tr>
<tr>
<td># of bikes who actually violate red lights</td>
<td>7</td>
<td>10</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>violation rate (policy)</td>
<td>54%</td>
<td>63%</td>
<td>43%</td>
<td>53%</td>
</tr>
</tbody>
</table>

Table 6 Bicyclists’ Who Violate the Red Light, Given an Opportunity

Bicyclists’ waiting behavior can be influenced by each other, this effect was not counted. The number of bicyclists queued for any given red light was usually only one, and rarely more than two.

**Queuing Position with Respect to First Stopped Car**

For bicyclists’ queuing behavior at red lights, only a small percentage, about 3% queued even with the first vehicle, not going ahead of it. For most of them, they queued in advance of the first stopping car. For all the bicyclists observed and recorded in the video, approximately 70% is queued fully ahead of the first car.

Vehicles are required to stop before the stop line. However, bicyclists feel safer if they get ahead of stopped cars to get priority from right turning vehicles or other potential competitors. Usually, if no pedestrian is walking on or blocking the crosswalk, bicyclists who arrive on red will feel comfortable to stay on crosswalk. It makes bicyclists not only have a priority from stopped cars, but also give them better view from traffic operating in conflicting direction.

As shown in Table 5, on Mass Ave at Sidney St, almost 84% of all bicyclists wait in front of cars by get to the front of the extended bike lane. This design has successfully guided bikes to stop at a safe place. Almost no bikes stopped on the sidewalk.
Waiting Position with Respect to Stop Line and Crosswalk

For bicyclists’ waiting position with respect to the stop line and crosswalk, only about 7% of all observed bicyclists stopped before front wheel cross the stop line. For most of them, they stopped only after their bike’s rear wheels were in or in front of the crosswalk. For all observed bicyclists, about 40% were waiting in the crosswalk, and about 33% were waiting beyond the crosswalk.

On Longwood Ave, almost no bicyclist waited beyond the crosswalk, while 68% bicyclists at Mass Ave and 29% bicyclists at BU Bridge did. This difference was based on the space that protected bicyclist from the traffic in the conflicting direction. On both Massachusetts Ave and BU Bridge, the curbs on the side of bike lane continue beyond the crosswalk to the conflicting traffic lane. The further the curb extended, which means more protection space for bicyclists, the more bicyclists were waiting beyond the crosswalk.

Even though many bikes waited in the crosswalk, almost no conflicts with pedestrians were observed.

Conclusion

In this study, bicyclist behavior at red lights was observed at three signalized intersections with different type of roads, traffic volume and different traffic facilities. Different behaviors were shown at different intersections. For the behavior of waiting for Green, the percentage of red light “compliant” bicyclists is higher when more number of lanes needs to be crossing at the intersection. In the result, about 63% of all stopped bicyclists waited for green. However, when opportunities for safely violating the red due to a break in conflicting traffic are accounted for, the fraction revealing a policy of violating the red was 53%, this fraction does not include bicyclists who jumped the yellow. Compliance rate was greater where cyclist had to cross a wider road. For bicyclist queuing behavior with respect the first stopped car, 71% of all bicyclists are waiting completely in front of the first stopped car. With respect to the stop line and crosswalk, 73% waited in the crosswalk, or beyond it, if there was a safe place to wait.
Bicyclists Departing from the Bike Lane in Commercial Areas

The purpose of a bike lane is to define a road space for bicyclists, separate from cars in order to decrease the level of stress of riding in traffic. At the same time, there are several criticisms about bike lane. One criticism is that bike lanes are blocked so frequently that bikes often have to go out into traffic, especially in commercial areas.

This study also selected three bike lanes in different commercial areas to observe how often a bike lane been blocked, forcing bicyclists to move into traffic.

Study Locations

Beacon St Westbound at St. Mary’s St, Brookline

Beacon Street westbound is comprehensive road that can accommodate multiple roadway users include motor vehicles, public transportation, pedestrian and bicyclists. An exclusive bike lane is located between parking lane and travel lane on Beacon St Westbound. The daily traffic volume on Beacon Street is about 20,000 and the Speed Limit on Beacon St is 30 mph. The section of bike lane studied is from St Mary’s Street to Carlton Street with a length of 650 feet. On the side of the study section, a lot of restaurants, convenience stores, super market and other commercial property are present. In the study section, a parking lane is located on the right. The parking meters allow up to 2 hour parking. Also, diagonal parking is on the left in a median with 2 hours metered parking. Along the study section, Beacon Street has No bus stops.

Commonwealth Avenue from Agannis Way to Packards Corner, Allston

Commonwealth Avenue is a major road that can accommodate all roadway users, such as motorists, pedestrians and bicyclists. The daily traffic volume on Commonwealth Ave is about 27,000 vehicles, with a speed limit of 30 mph. The study section is about 0.3 miles long, going westbound from Agannis Way/Pleasant Street to Packards Corner with exclusive bike lane on the side. Along the study section, a lot of university facilities, restaurants, franchise stores and other commercial properties are present. On Commonwealth Avenue westbound from Agannis Way to Pakards Corner, a parking lane is present on the right, the parking meters also allow up to 2 hours parking. In addition, MBTA Route 57 bus goes through the study section, 3 bus stops were located in the study section, according to MBTA bus schedule, between 4 and 6 pm, the number of buses go through this section is about 19, with a headway approximately 6.3 seconds.
However, demand at these stops is very low, because most transit users use the streetcars, therefore, buses often pass by stops without stopping.

**Massachusetts Ave at Central Square, Cambridge**

The study section on Massachusetts Ave is from Norfolk St to Inman St northbound. Within the study section, Massachusetts Ave goes through Central Square. An exclusive bike lane is marked on both sides of Massachusetts Ave. The study section “features a rich variety of shops, restaurants, civic organizations, and other interesting establishments. Frequent by students and professors, business people, visitors, and residents, Central Square establishments offer a bit of everything, all in one convenient place.” Parking lane which allow up 2 hours meter parking is present in part of study section. Two bus stops close to the Central Square intersection are heavily used. In PM peak hours, bus is going through the study section about every 5.5 minutes.

**Data Collection**

The purpose of this research is to study how commercial activities can influence bicyclists’ activity to ride in the marked bike lane. The data collection time at each location is from 4PM to 6PM on weekdays, which is believed as the commercial peak hour, as well as the time with most traffic volume and bicycle volume.

Unlike previous data collection in this research, this study is to record bicyclists behavior in a section of bike lane instead of at a study point. The author stood at a point where a bicyclist can be observed from the start to the end of the study section. Sometimes a video was recorded to make sure no bicyclists were uncounted.

In order to study how often bicyclists have to leave the bike lane because of traffic and commercial activities, bicyclists who leave the bike lane for other reasons will be discarded. Those include bicyclists who turn out to or turn in from a connection road before the destination, bicyclists parked on the sidewalk within the study corridor who joined the bike lane partway through the study section.

**Analysis and Discussion**

With two days data collection at each location, 66 bicyclists on Beacon St were recorded, 125 bicyclists on Commonwealth Avenue and 123 bicyclists on Massachusetts Avenue. As shown in Table 7, more than 40% bicyclists at each location left the bike lane because of commercial activities. This is an impressive rate as almost one of two bicyclists will have to leave the bike lane at each commercial area. The study sections are only one
section of the entire bike lane, so it stands to reason that if the study area gets longer, more bicyclists will have to do so.

<table>
<thead>
<tr>
<th></th>
<th>Beacon St @ St. Mary St</th>
<th>Commonwealth Ave</th>
<th>Mass Ave@ Central Square</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td># bikes left the bike lane</td>
<td>29</td>
<td>59</td>
<td>60</td>
<td>148</td>
</tr>
<tr>
<td># bikes Observed</td>
<td>66</td>
<td>125</td>
<td>123</td>
<td>314</td>
</tr>
<tr>
<td>rate of bike left bike lane</td>
<td>44%</td>
<td>47%</td>
<td>49%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Table 7 number of bikes leaving out the bike lane at selected locations

The reason force bicyclists to leave bike lane are various, in the data collection process, the following reasons have been recorded:

- **Bus**: When a bus pulls in or pulls out a stop, it is common to see the big vehicle entirely blocking the bike lane. (Figure 16)
- **Commercial Unloading**: Such as Post Office Truck, Cargo Truck is easy to see double parking on the bike lane area. (Figure 17)
- **Dooring**: Parked cars or Taxi hazardously open the door to unload passenger will force bicyclists leave the bike lane
- **Double Parking**: In commercial area with street parking, it is hard to find a parking space at peak hours; a number of drivers will double the car and block the bike lane. This category excludes taxis.
- **Taxi Double Parking**: Taxi are used to stopping anywhere they want
- **Parking Maneuvering**: Cars pull into or pull out of a parking space and block the bike lane
- **Yield to Pedestrian**: Some bicyclists have been viewed to yield to non-compliant pedestrians and move out bike lane
- **Right Turning Vehicles**: Right turning vehicles always block bikes
- **Side by Side**: Sometimes, two or more bicyclists are riding simultaneously which makes one or more ride out of bike lane
- **Sidewalk**: Sometimes a bicyclist will move from the bike lane to the sidewalk to visit a store, or may use the sidewalk because the bike lane isn’t safe
- **No Reason**: Some bicyclists will not ride in the bike lane even when it isn’t blocked. They feel comfortable and safely to ride in the travel lane
- **All Double Parking**: Commercial Unloading, Double Parking, and Taxi Double Parking can be combined.
Figure 16 Bus Pulling in to Bus Station Blocked the Bike Lane

Figure 17 Commercial Unloading Truck Blocks the Bike Lane
Figure 18 A bicyclists blocked by Taxi making an in or out maneuver

Figure 19 Double Parking Cars Blocked Bike Lane
As a result, 314 bicycles were observed at three commercial areas. The total number of bicycles rode out of the bike lane was 148, which is 47% of all observed bikes. In the three studied locations, Mass Ave at Central Square has the highest percentage of bikes moved out of the bike lane, which is 49%, the lowest percentage wasn’t much different, 44% on beacon street.

All the bikes that left the bike lane have been categorized by different reason of moving out the bike lane. The fraction of every category has been calculated as shown in Table 8. Two types of fraction have been calculated. The first is the fraction of those who left the bike lane. The second is the fraction of all observed bikes.

While the percentage of leaving bike lane was very similar at the 3 locations (44%, 47% to 49%), the main reason was different at the three locations. At Beacon St, the most important reasons were double parking, parking maneuvering, and dooring. At Commonwealth Ave, the most important reasons were parking maneuvering, double parking, right turning vehicles, and dooring. On Massachusetts Ave at Central Square, most bicyclists left the bike lane because of Bus pull in or pull out, double parking, and dooring.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Beacon St @ St. Mary St</th>
<th>Commonwealth Ave</th>
<th>Mass Ave @ Central Sq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>0%</td>
<td>8%</td>
<td>23%</td>
</tr>
<tr>
<td>Commercial Unloading</td>
<td>7%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>Dooring</td>
<td>14%</td>
<td>12%</td>
<td>6%</td>
</tr>
<tr>
<td>Double Parking</td>
<td>31%</td>
<td>15%</td>
<td>7%</td>
</tr>
<tr>
<td>Parking Maneuvering</td>
<td>24%</td>
<td>29%</td>
<td>14%</td>
</tr>
<tr>
<td>Yield to Pedestrian</td>
<td>3%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Taxi Double Parking</td>
<td>17%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>Right Turning Vehicles</td>
<td>0%</td>
<td>15%</td>
<td>7%</td>
</tr>
<tr>
<td>Side by Side</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>Sidewalk</td>
<td>0%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>No Reason</td>
<td>3%</td>
<td>2%</td>
<td>10%</td>
</tr>
<tr>
<td>All Double Parking(^{(1)})</td>
<td>55%</td>
<td>24%</td>
<td>25%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

\(^{(1)}\)All Double Parking Rate Equals to the Sum of Commercial Unloading, Double Parking and Taxi Double Parking

Table 8 Fraction of Different Reason Cause Bike Left the Bike Lane

38
As observed when collected data at different locations, a bicyclist may leave the bike lane twice or even more in a short section by different reasons. This frequent influence by such commercial activities will increase the level of stress for bicyclists. Some of them may choose to ride on the sidewalk or even give up bicycling at such locations.

Conclusion

When an exclusive bike lane is marked in commercial areas, it is common to see bicyclists riding out of the bike lane. In peak hours, almost 50% bicyclists rode out of the bike lane at all three study locations.

Less than 10% of bicycles left the bike lane to ride on the sidewalk or to ride side by side. More than 80% of the bicyclists who left the bike lane were influenced by commercial activities.

As in all of the study locations, it is illegal to double park, and specifically illegal to park in a bike lane. Still double parking cars at these locations significantly hinder bicyclists, as they occupied the bike lane for a long period. It is important to prohibit the double parking by enforcement and law.

Also, as the intense demand for access to the curb makes bike lanes in commercial areas inherently unsafe. It is important and useful to move bikes from those obstacles. Therefore, a bike lane with physical separation can be adopted, such as cycle track, an exclusive bike facility that has elements of a separated path and on-road bike lane. By installing cycle tracks, bikes in commercial area will physically separate from motor traffic.
References

7. Massachusetts Bay Transportation Authority, (http://www.mbta.com/schedules_and_maps/subway/lines/stations/?stopId=15591)