When Do Drivers Yield to Cyclists at Unsignalized Roundabouts? 
Empirical Evidence and Behavioral Analysis

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Cycling has grown in popularity during the past decades in many cities in Europe and in the United States because of its environmental and health benefits. However, cyclists are frequently involved in traffic accidents, especially when they interact with vehicles at signalized intersections. There is still a lack of evidence and of analysis of what happens in such interactions. This paper explores empirical evidence of vehicle–bicycle interactions on a typical Swedish roundabout and provides insights into factors that influence car drivers’ yielding decisions when they interact with cyclists. Vehicle–bicycle interactions were divided into groups (nonconflict, conflict, yield, and nonyield), and their speed differences were analyzed by group. Furthermore, a discrete choice model was developed to estimate behavioral aspects of such interactions. The observed data showed a higher and significant speed variation among vehicles compared with bicycles, which exhibited smaller variation across groups. The modeling results revealed that the probability of yielding decreased when the speed of the vehicle was higher. But a bicycle’s speed had little effect on a driver’s decision to yield. More important, the probability of yielding was increased significantly by the proximity of the cyclist to the conflict zone. The yielding rate of drivers can be improved by keeping vehicles’ speed to less than 20 km/h, as drivers then have the capacity to detect and yield to cyclists.

Bicycling, as a nonmotorized mode, is becoming increasingly relevant in transport planning because of its potential benefits for energy usage, the environment, and health. Researchers and public authorities consider bicycling to be a mode of transport and cyclists to be travelers; thus, bicycling is no longer considered only a recreational activity. In Stockholm, Sweden, the number of cyclists has been increasing in the past decade, especially for trips toward the inner city (1). In addition, a number of bicycle-sharing systems have been introduced (and have become popular) in many cities around the world, overcoming some of the problems related to bicycling, providing means for one-way trips, and supporting public transport systems (2, 3). However, bicycling safety is still a focus of attention; a better understanding of bicycling needs and of bicycling’s relationships with other modes of transport is needed. Bicycling’s interactions with motorized vehicles is a crucial aspect of this mode for the public, practitioners, and researchers.

According to the literature, vehicle–bicycle interactions can be divided into three main types:

- **Longitudinal interaction** (vehicle–bicycle interaction next to links). This situation arises when cyclists travel on a bicycle lane or path next to the traffic stream. Safety considerations are mainly the width of the bicycle lane or path, vehicles’ speeds, and vehicle and bicycle volumes (4–7).
- **Mixed interaction** (vehicle–bicycle longitudinal interaction within links). This interaction occurs when drivers and cyclists share the road without any physical barrier to separate the travel modes. Safety considerations are the road width, overtaking opportunities, lateral lane position, vehicle and bicycle speeds, and vehicle and bicycle volumes (8, 9).
- **Crossing interaction** (vehicle–bicycle interaction at crosswalks). Two types of crossings can be considered: signalized and unsignalized intersections. At signalized intersections, traffic lights allow separation of primary conflicts. The remaining secondary conflicts (e.g., a vehicle is turning right or left and a cyclist is heading through the intersection) may lead to serious conflicts and accidents. On the other hand, at unsignalized crossings (including roundabouts), priority rules govern vehicle–bicycle interactions.

Normally, according to the traffic regulations in Sweden, cyclists have priority over vehicle traffic at unsignalized crosswalks. However, in reality, this priority rests on expectations and assumptions—that is, on the expectation that the driver has detected the approaching conflicting cyclist and the driver is able or willing to give way (10). According to Svensson and Pauna, the yielding rate increases as the bicycle flow increases and when yield signs are located before the crossing (11). Further, drivers’ yielding rate to cyclists is reported to be, on average, 58% in Sweden. Consequently, there is still a large proportion of drivers who do not comply with the expectation that they will yield to cyclists. Other studies have shown that the yielding rate decreases as the speed of the vehicle increases because the driver has less time to detect, and react to, the presence of cyclists (12).

In Sweden, vehicles that are exiting roundabouts should yield to pedestrians and cyclists on the crosswalks. According to the literature, there is a large percentage (>40%) of car drivers who fail to yield as expected. From a behavioral perspective, it is important to identify factors that might contribute to this large percentage of failures to yield. One of the most important factors is the speed of the vehicle. According to Räsänen and Summala, drivers of vehicles moving at higher speeds have difficulty in observing cyclists, leading to a failure to yield (13). At high speeds, car drivers have less

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time to detect cyclists and to react accordingly. For instance, Summala et al. investigated drivers’ visual searches when interacting with cyclists at T-intersections governed by priority rules in Finland (14). They found that drivers who were turning right focused their attention on traffic coming from the left; they scanned the right leg of the intersection less frequently and also later in the process. The authors explained the behavior as one where drivers focused on the left because they considered traffic on the left to be much more frequent and dangerous, compared with traffic on the right, during the critical phase. They evaluated the impact of speed bumps on drivers’ visual searches as well and concluded that speed reduction measures can result in lower vehicle speeds, thus giving drivers more time to focus on cyclists approaching from the right. In another study, an in-depth analysis of vehicle–bicycle collisions was conducted (15). The authors investigated and reconstructed more than 180 vehicle–bicycle accidents in Finland. In 37% of the collision cases (related directly to two-way bicycle pathways and intersections governed by priority rules), neither the driver nor the cyclist realized the presence of, or yielded to, the other party. The authors identified two mechanisms underlying the collisions: (a) lack of attention resulting in not detecting other road users and (b) unjustified expectations with respect to the behavior of the other road user. The most common collision involved vehicles turning right and cyclists approaching from behind on the right side of the vehicle. One explanation was that drivers pay more attention to the traffic on the left. In these accidents, 11% of the drivers did notice the cyclist just before impact. On the other hand, 68% of the cyclists noticed the driver and 92% of those cyclists believed that the driver would yield as expected (15).

Wood et al. evaluated drivers’ perceptions and attitudes toward cyclists (16). The authors reported that most of the vehicle–bicycle crashes were caused by the driver not being able to see the cyclist in time to avoid the collision. They also found that cyclists overestimated the distance at which they would be recognized by a driver by almost 100%. Another important aspect of the vehicle–bicycle interaction is the risk perception, that is, how dangerous a traffic situation is perceived to be by either the cyclist or the driver. Chaurand and Delhomme evaluated several common vehicle–bicycle crash situations and found that the perceived risk of an accident decreased with experience for both cyclists and drivers in such situations (17). They also found that the perceived risk was higher for drivers compared with cyclists in the same traffic situation.

Understanding vehicle–bicycle interactions is still an important topic for investigation. Two main issues were identified through literature review. The driver’s ability to detect and react to an approaching cyclist during a right-turning maneuver should be further investigated. More important, the driver’s yielding decision process and the factors that influence it, especially at unsignalized crosswalks, should be better understood so that models and tools can be developed to facilitate the evaluation of different policies or engineering treatments for a better bicycling environment.

Therefore, this paper aims at collecting and analyzing empirical evidence of the vehicle–bicycle interaction process at an unsignalized roundabout. Such evidence can provide insights into factors that influence drivers’ decisions to fulfill other users’ expectations. Specifically, the factors directly affecting the yielding decision of drivers are explored with the use of statistical modeling approaches. The next section describes the data collection and analysis procedures, followed by a section that presents a statistical approach to modeling the yielding decision process by car drivers. Then the empirical results and discussion on the essential factors obtained by model estimation are presented, followed by a conclusion.

DATA COLLECTION AND ANALYSIS

Vehicle–Bicycle Interaction Zones

Generally, in Sweden, teamwork is promoted among drivers within the traffic system to support polite and safe interactions. Unsignalized crosswalks are normally governed by priority rules. Drivers exiting a roundabout have the responsibility to give way to any other road user traversing a crosswalk. Normally, before drivers reach a crosswalk, they are expected to look upstream along the sidewalk or road for the possible presence of cyclists. Similarly, cyclists are expected to look for vehicles as they approach a crosswalk to ensure a safe crossing. Because of the different dynamics, the area of vehicle–bicycle interaction comprises two important zones:

- A conflict zone (CZ) where the vehicle and bicycle trajectories meet or cross with potential collision if trajectories are sustained and
- An interaction zone (IZ) where the driver and the cyclists begin to interact or negotiate to avoid a potential collision.

The CZ zone is often painted at priority intersections (including roundabouts) and can be considered the whole crosswalk. Therefore, the CZ is a common, overlapping area for both vehicles and bicycles. On the other hand, different vehicle and bicycle dynamics, such as speed, acceleration, reaction times, and braking forces, imply that drivers and cyclists begin monitoring each other at different locations from the CZ. Therefore, two interaction zones are defined:

- The car IZ begins at the CZ and extends further into the roundabout.
- The bicycle IZ begins at the CZ and extends further upstream into the sidewalk or bicycle path or lane.

Each IZ has different lengths because of different vehicle and bicycle characteristics. The car IZ extends up to 10 m from the CZ. Because of the specific geometry of the studied roundabout, the driver has full visual coverage of the sidewalk at 10-m distance from the CZ. The driver can detect the presence of cyclists and is able to react and decide whether to fulfill the expectation that he or she will yield expectation or not. Therefore, the location is considered the decision point for drivers and may vary among different facilities and drivers. On the other hand, the bicycle IZ extends up to 30 m from the CZ, divided into three segments of 10 m each. The segments are defined as S1, S2, and S3, as shown in Figure 1a.

Data Collection

To investigate drivers’ yielding behavior, vehicle and bicycle trajectories are needed. Information on the presence of yielding events is also crucial for the analysis. As a result, data acquisition to analyze drivers’ yielding decisions is a labor-intensive task. One way to ease and overcome such difficulties is by video recordings and data extraction using image processing. During data collection, vehicle–bicycle interactions at a typical roundabout in Stockholm—a one-lane roundabout near Stockholm University—were observed. The data were collected on a weekday in the autumn of 2013 during the afternoon rush hour (16:00 to 18:00). Weather conditions were dry and clear.

Video equipment was used to capture vehicle–bicycle interactions. A mast tower of 15 m in height with two cameras was installed and configured to visually cover the conflict and interaction zones. The video cameras saved the images for later processing. A video analysis
program called Semi-Automatic Video Analysis (SAVA) (18) was used for data extraction. After image calibration, the program allows the drawing of virtual lines on the film so that moving objects can be traced as they traverse the study area. A log file is created with subject identity and time stamps at each virtual line. Speed can be derived afterward from the time and distance recorded. The yielding events were also identified from the video observations on the basis of drivers’ decelerations or speed adaptations to let a cyclist traverse the crosswalk safely. Figure 1b shows the film analysis with some virtual lines drawn. Figure 1c illustrates drivers’ angles of vision, and Figure 1d illustrates cyclists’ angles of vision, at the beginning of their respective interaction zones.

Event Groups

When a vehicle exits a roundabout and passes through a bicycle crossing, either a nonconflict or a conflict event may take place:

- Nonconflict. The driver does not encounter any cyclists, thus crossing the CZ freely and leaving both the IZ and the CZ zones without interruption.
- Conflict. The driver interacts with the cyclist because of a potential collision.

It is assumed that there is a conflict if a vehicle and a bicycle are simultaneously in their respective IZ. The arrival time difference (ATD) between the vehicle and the bicycle at the boundary of each interaction zone is the key variable in establishing a conflict event. Larger ATD values imply that it is less likely that the trajectories of the vehicle and bicycle will meet at the CZ; shorter ATD values indicate that it is likely the driver will perceive a conflict. From video observations and the ATD values at the boundaries of each IZ, a threshold of 5.5 s was identified to discriminate between nonconflict and conflict events. On the basis of this threshold, observations were classified into the following categories:

- Nonconflict: ATD > 5.5 s and
- Conflict: ATD ≤ 5.5 s.

Furthermore, where there is a conflict, a driver may have two options:

1. Yield to the interacting cyclist or
2. Pass through the IZ and CZ zones without yielding to the interacting cyclist.

Therefore, a conflict can lead to one two subsequent events:

- Nonyield: the driver does not yield, given ATD ≤ 5.5 s, or
- Yield: the driver yields, given ATD ≤ 5.5 s.
Finally, the vehicle–bicycle interaction events can be classified into four categories as follows: Nonconflict, Conflict, Yield, and Nonyield for vehicles and bicycles. In the case of a bicycle, Yield refers to a cyclist interacting with a driver who does yield and, similarly, for the other groups.

**Data Analysis**

Table 1 summarizes descriptive statistics of various measures of interest. Statistical tests at $\alpha = 5\%$ level of significance were conducted to test the null hypothesis that the means are the same. The tests indicated that the differences were significant in most of the cases. For instance, the mean vehicle speed difference between the nonconflict and conflict groups is 2.90 km/h ($t$-statistic = 2.55). As expected, vehicles interacting with bicycles have lower speeds in comparison with nonconflict (free) vehicles. The mean vehicle speed difference between the conflict and yield groups is 6.16 km/h ($t$-statistic = 11.88). Naturally, yielding vehicles present the lowest mean speed of all vehicle groups because their drivers alter their speed to let cyclists traverse the crosswalk safely. It was expected that the nonconflict group would present the highest speed, given no disturbance from any cyclist. However, it is interesting to observe that the speed difference between the nonconflict and nonyield groups is negligible, with 0.04 km/h difference ($t$-statistic = 0.03).

In the nonyield case, it can be argued that either the driver did not detect the cyclist or the cyclist was far enough from the CZ that the driver had the opportunity to go through the CZ before the cyclist.

Cyclists, on the other hand, present lower speed variation across the classified groups. The mean speed difference between the conflict and yield groups is 0.57 km/h ($t$-statistic = 1.39). The speed difference is not statistically significant. This small difference can be an indication that cyclists try to force drivers to decide to yield because cyclists are confident of their priority and do expect drivers to yield. This reveals a risky behavior on the part of the cyclist—that is, the cyclist is confident that the driver has detected him or her and will react to his or her presence. As mentioned earlier, Wood et al. report that cyclists overestimate the distance at which they would be recognized by a driver by almost 100% (16). The fastest bicycle group is the nonconflict group, with a mean speed of 16.82 km/h. Of course, it was expected that this group would have the highest speed because they were not disturbed by any vehicles. The bicycle group with the lowest speed is the yield group, with a mean speed of 15.77 km/h. The speed difference between the nonconflict and the yield groups is small (1.05 km/h).

Figure 2 shows a plot of the cumulative speed distributions for all vehicle and bicycle categories. Vehicle speed differences are clearly distinguished, especially the speed difference of the yield group (solid line) compared with all other vehicle groups (Figure 2a). The results suggest that the nonyield group has basically the same speed as the nonconflict group. Figure 2a also shows that more than 90% of the drivers who yielded had a speed of less than 20 km/h.

<table>
<thead>
<tr>
<th>Event Group</th>
<th>Vehicle Speed (km/h)</th>
<th>Bicycle Speed (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>All data</td>
<td>20.12</td>
<td>5.80</td>
</tr>
<tr>
<td>Nonconflict</td>
<td>21.93</td>
<td>4.78</td>
</tr>
<tr>
<td>Conflict</td>
<td>19.03</td>
<td>6.09</td>
</tr>
<tr>
<td>Yield</td>
<td>12.87</td>
<td>3.88</td>
</tr>
<tr>
<td>Nonyield</td>
<td>21.89</td>
<td>4.65</td>
</tr>
</tbody>
</table>

**FIGURE 2** Vehicle and bicycle cumulative speeds by group and scatter plot: (a) vehicle speeds by group and (b) bicycle speeds by group.
Similarly, bicycle speed profiles for different event groups are presented in Figure 2b. Again, the yield group (solid line) demonstrates the lowest speed level. In addition, Figure 2c shows a scatter plot of vehicle speeds versus bicycle speeds, considering the cyclist’s location by IZ segment and whether the driver from the conflict group yielded or not. The plot indicates that low-speed vehicles produce a higher yielding rate. This result supports the idea that drivers have more time to detect and react to a cyclist’s presence at low speeds. At high speeds, drivers do not yield as expected. The results suggest that the position of the cyclist plays an important role in the driver’s decision. Most of the nonyield observations occur with drivers at speeds of more than 18 km/h and cyclists in S3 (>20 m)—that is, the results show that the yielding rate decreases with higher vehicle speeds and with larger distances from the bicyclist to the CZ.

**MODELLING THE PROBABILITY OF YIELDING**

The data analysis provides useful insights on the probability of yielding. The substantial difference between free vehicles and vehicles interacting with bicyclists, for example, indicates that the yielding probability is significantly affected by vehicle speed. Bicycle speed had a relatively small effect, according to the lower variation among the groups. Additionally, the proximity of cyclists to the conflict zone should have some effect on drivers’ yielding decisions. The analysis in this section aims at developing a model that identifies the factors that explain these decisions. The explanatory variables considered are summarized in Table 2.

Logistic regression, a statistical approach appropriate for modeling binary response data, was used to estimate the model [similar approaches have been used to investigate vehicle and pedestrian interactions (19)]. The probability of yielding, given that vehicle–bicycle conflict takes place, is given by a logit model:

\[ P(Y = 1|X) = \frac{e^{V(X)}}{1 + e^{V(X)}} \]  (1)

\[ V(X) = X \cdot \beta = \beta_0 + \beta_1 x_1 + \cdots + \beta_5 x_5 \]  (2)

where \( \beta = [\beta_0, \beta_1, \ldots, \beta_5]^T \) is a vector of parameters and \( X = [x_1, x_2, \ldots, x_5]^T \) is a vector of explanatory variables that determine the final yielding probability. The models, with different specifications, were estimated using IBM SPSS (20).

**RESULTS**

Three models were estimated. Model 1 relates the yielding probability to the speed of the vehicle. Model 2 relates the yielding probability to the speeds of the vehicle and the bicycle. Model 3 includes

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Variable Descriptions</th>
</tr>
</thead>
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<tr>
<td>Parameter</td>
<td>Variable</td>
</tr>
<tr>
<td>( \beta_0 )</td>
<td>na</td>
</tr>
<tr>
<td>( \beta_1 )</td>
<td>( V_{car} )</td>
</tr>
<tr>
<td>( \beta_2 )</td>
<td>Segment 1</td>
</tr>
<tr>
<td>( \beta_3 )</td>
<td>Segment 2</td>
</tr>
<tr>
<td>( \beta_4 )</td>
<td>Segment 3</td>
</tr>
<tr>
<td>( \beta_5 )</td>
<td>( V_{bike} )</td>
</tr>
</tbody>
</table>

Note: na = not applicable.
TABLE 3  Estimation Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>( \beta_0 )</td>
<td>5.762</td>
<td>3.591</td>
<td>3.547</td>
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<tr>
<td></td>
<td></td>
<td>(29.12)</td>
<td>(7.73)</td>
<td>(7.00)</td>
</tr>
<tr>
<td>( V_{cy} )</td>
<td>( \beta_1 )</td>
<td>-0.411</td>
<td>-0.404</td>
<td>-0.408</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(41.09)</td>
<td>(23.80)</td>
<td>(22.37)</td>
</tr>
<tr>
<td>Segment 1</td>
<td>( \beta_2 )</td>
<td>na</td>
<td>na</td>
<td>4.890</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(23.77)</td>
</tr>
<tr>
<td>Segment 2</td>
<td>( \beta_3 )</td>
<td>na</td>
<td>na</td>
<td>4.289</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(13.56)</td>
</tr>
<tr>
<td>Segment 3</td>
<td>( \beta_4 )</td>
<td>na</td>
<td>na</td>
<td>2.680</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(7.58)</td>
</tr>
<tr>
<td>( V_{cycl} )</td>
<td>( \beta_5 )</td>
<td>na</td>
<td>0.236</td>
<td>na</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(24.63)</td>
</tr>
<tr>
<td>(-2) log likelihood</td>
<td>na</td>
<td>101.210</td>
<td>62.396</td>
<td>55.323</td>
</tr>
<tr>
<td>Nagelkerke R²</td>
<td>na</td>
<td>.579</td>
<td>.768</td>
<td>.798</td>
</tr>
</tbody>
</table>

Note: Wald statistics appear in parentheses. Yielding events = 37; observations = 187.

the cyclist’s proximity in the estimation. The estimated models are presented in Table 3. The \(-2\)LL and Nagelkerke R-square values suggest that Model 3 is the preferred model; its probability estimates are depicted in Figure 3a. The plot shows how the presence of cyclists in S1 and S2 relates to higher yielding rates compared with cyclists located in S3 (\( y = 1 \) represents a yielding event). Figure 3b exhibits the probability estimates from Model 2 with the speed of the bicycle fixed at three levels (10, 15, and 20 km/h). The a priori expectation was that higher vehicle speeds lead to lower yielding probabilities. It was also expected that cyclists closer to the CZ zone would have a greater effect on the driver. According to the results, the speed of the vehicle is negatively correlated with the yielding event, as expected. A vehicle with high speed has a lower chance to fulfill the yielding expectation because at high speeds drivers have less time to detect and react to the presence of an interacting cyclist.

This finding is also in line with previous literature (12, 15).

The effect of the proximity of the cyclist approaching the CZ agrees with the expectations as well. A cyclist in S1 is related to higher yielding probabilities, compared with the case where there is no cyclist. According to the results, if a driver encounters a cyclist in S1, the probability of yielding increases from 40% to 90% when the vehicle speed decreases from 22 km/h to 15 km/h. There is still a small chance (10%) of yielding if the vehicle speed is 26 km/h. In S2, if a driver interacts with a cyclist, the yielding probability almost doubles when the vehicle speed decreases from 21 km/h to 14 km/h. Of course, if the driver fails to yield, the cyclist is expected to yield and to wait for the driver, in order to avoid a collision. Consequently, S1 and S2 show a sustained influence on drivers’ yielding decisions. Hence, the presence of the cyclist up to 20 m away from the CZ has a strong impact on driver behavior. On the other hand, the presence of the cyclist in S3 (>20 m) shows a lower effect on the yielding probability, which decreases significantly. For instance, Figure 3a shows that a driver whose speed is 20 km/h and who detects a cyclist in S3 has only a 10% probability of yielding. If the cyclist is detected in S2, the probability of yielding increases to 40%; if the cyclist is in S1, the probability of yielding increases to 55%. Therefore, the closer the cyclist is to the CZ, the greater the effect on the driver is, despite the vehicle speed. The effect of the distance of the bicyclist from the CZ should be further investigated. For example, bicyclists who are far away may affect drivers in the opposite direction by encouraging them to accelerate instead of yielding, as was observed in the video recordings. The bicycle speed is positively correlated with the yielding probability, according to the results. Figure 3b shows that a driver whose speed is 20 km/h has a 10%, 30%, and 50% probability of yielding for bicycles with speeds of 10, 15, and 20 km/h, respectively.

Model 1 and Model 2 have an overall accuracy of 89.9% and 92.5%, respectively, in predicting yielding decisions. On the other hand, Model 3 has an overall accuracy of 94.1%. Out of 37 observed yielding events, Model 3 was able to predict 30 yielding events accurately; in the same way, it successfully predicted 145 nonyielding events out of 150 nonyielding observed events. However, it erroneously predicted five yielding events that, in reality, were nonyielding events and predicted six nonyielding events that were actually yielding events.

CONCLUSION

Understanding driver yielding behavior and factors that influence it is important for guiding informed design, planning, and even policy decisions. Apart from geometric factors and driver characteristics, which also play an important role in such decisions, other aspects, such as the vehicle’s and bicycle’s speeds and their relative positions, provide insights that allow better understanding of the decision process.

FIGURE 3  Yielding probabilities: (a) cyclist proximity and (b) bicycle speed.
behind yield or nonyield events. The results indicate that low speed vehicles have a high yielding rate. The nonconflict and nonyield groups presented the highest mean speed of all groups (21.9 km/h). The nonyield group can be considered as relatively risky drivers. Another interesting result from the data analysis is that the mean speed difference between the nonyield and the yield groups is 9 km/h. This result undoubtedly shows the effect of vehicle speed on the yielding decision. On the other hand, cyclists are very confident of their priority at intersections and try to force a yielding decision on drivers, as implied by the small speed difference (1.0 km/h) between the nonconflict and yield bicycle groups.

The results also show that the relative position of the cyclist is an important factor in the yielding decision. A positive effect (increased yielding rate) is reported as cyclists get closer to the CZ. The results also indicate that the effect is sustained for distances up to 20 m away from the CZ. At a distance larger than 20 m, the effect of the cyclist’s relative position is reduced substantially. Besides, it is possible that cyclists far away from the CZ (>30 m) still have an effect on drivers’ yielding decisions, although in the opposite direction; that is, the driver detects that the cyclist is far away and the distance induces the driver to speed up rather than slow down. The distance threshold where the cyclist’s influence ceases or changes suddenly (e.g., decreased yielding rate) is still a subject of investigation.

The data analysis indicates that there is not much variability in bicycle speed across the groups. Model 2 also confirms that the cyclist’s speed has a small effect on the driver’s decision to yield. The estimation results in Model 3 suggest that the position of the cyclist has a strong influence on driver behavior. This also implies that detecting the cyclist is crucial for drivers’ yielding decisions. In addition, the results show that for vehicle speeds below a certain threshold (20 km/h for the studied roundabout), the probability of yielding increases rapidly as the cyclist gets closer to the CZ. In general, the results provide a better understanding of how drivers decide whether to yield to cyclists at one-lane roundabouts.

The results presented in the study reflect behavioral aspects and the geometric configuration of a typical Swedish roundabout governed by local traffic regulations. Car drivers have the responsibility to give way to cyclists, who may simply traverse the crosswalk. Therefore, the applicability of the results in other contexts, especially outside the Nordic countries and Europe, should be examined further.

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REFERENCES


