Driver performance around bicyclists and bicycle-specific infrastructure

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Aim: Examine driver behavior during interactions with bicyclists

Risk of fatal injury is increased when a bicycle crash involves a motor vehicle

Driver age and gender may influence crash risk

Bicycle infrastructure is increasingly used to separate bicyclists from motor vehicles, and improve road safety

There are many types of bicycle-specific infrastructure with varied impacts on safety
Study Process

- Literature Review
- Naturalistic Cycling Data Analysis
- Design simulator events
Naturalistic Cycling Analysis

10 adult and 10 child bicyclists (1 week each, ~57hrs), video and GPS

Safety-relevant events (SRE)

- 83.8% at intersections
- 73.7% bicycling riding to the right side of the lane
- 10.1% bicyclist on sidewalk
- 45.8% riding forward, with traffic
- 31.3% turning right
- 86.6% at stop sign

Highest rates of safety-relevant events were on paved street with no bicycle facility followed by off-street bicycle path

90% SREs were traffic violations (61% Incomplete stops, 28.9% Complete failure to stop or yield)
Common bicycle crash types and characteristic from literature review

Motorist overtaking bicyclist traveling in the same direction

Intersections

Failure to yield at mid-block

Right hook type
Simulation event selection parameters

- Crash and injury risk
- Event frequency during bicycling
- Gaps in literature
- Feasibility within simulation and larger study design
FINAL SELECTED EVENTS

1. Overtaking with and without shared lane markings

2. Right turn across path of bicyclist in bike lane

3. Bicycle crossing perpendicular in front of motor vehicle at midblock on a bike path
Overtaking
Overtaking event – Simulation

Shared lane marking  No shared lane marking
Right Turn Across Path
Bicycle path crossing
RESULTS
Participants

59 enrolled, 48 completed the study (24 male, 24 female)

Inclusion criteria: Valid U.S. driver’s license, able to meet study timeline

Exclusion criteria: medical exclusions (e.g., diagnosis with current serious illness, heart condition, pregnancy)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Novice (18-25)</th>
<th>Young (26-40)</th>
<th>Middle (41-60)</th>
<th>Older (61-80)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N = 48</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Age, Mean (SD)</td>
<td>22.8 (1.7)</td>
<td>33.4 (4.3)</td>
<td>49.8 (4.7)</td>
<td>71.4 (4.5)</td>
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Overtaking: Closest Approach

In the Shared Lane Marking group, no driver had closest approach distance of less than 3 feet vs 37.5% of drivers in the No Shared Lane Marking group

Mean closest approach
- Shared lane marking group: 5.7 feet (SD=1.8)
- No Shared lane marking group: 4.1 feet (SD=2.0)

*P<0.01
Motorist overtaking patterns

Shared lane markings present

Shared lane markings absent

Bike paths shown in **green**, vehicle paths in black
Overtaking: deceleration and time spent on collision course

Novice drivers (18-25) in the no shared lane marking group had greater max deceleration values compared to the other age groups. This difference was not found in the shared lane marking group.

The total time spent on a collision course with the bicyclist was higher in the no shared lane marking group (4 seconds, SD=3.6 vs 0.1 seconds, SD=0.03)

*P<0.01
Overtaking: passing distance and lane changing

Older drivers (61-80 years old) in the no shared lane markings group gave less average passing distance, compared to shared lane marking group: 2.8 ft vs. 5.8ft, p<0.01

81.3% of participants (both groups) did not make a complete lane change to overtake bicyclist.
RESULTS—Right Turn Across Path
Mean wait time decreased with age

<table>
<thead>
<tr>
<th></th>
<th>Novice (18-25)</th>
<th>Young (26-40)</th>
<th>Middle (41-60)</th>
<th>Older (61-80)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wait time (seconds)</td>
<td>4.9 (2.3)</td>
<td>3.8 (1.2)</td>
<td>3.6 (2.7)</td>
<td>1.8 (1.9)</td>
<td>0.01</td>
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Right turn across path results

Mean and minimum speeds increased with age (p=0.02)

Mean glance reaction times were longer for males (0.6 seconds), compared to females (0.3 seconds), p=0.28

Closest approaches did not vary significantly by age or gender (p=0.61)

No collisions and no hard acceleration (>0.4g) in turn for all participants
Bike path crossing: Braking and deceleration

Maximum brake force was higher in the middle and older age groups compared to novice and young age groups.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Max Braking Force, lbf</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice 18-25</td>
<td>18.9 (4.6)</td>
<td>0.11</td>
</tr>
<tr>
<td>Young 26-40</td>
<td>23.9 (14.8)</td>
<td></td>
</tr>
<tr>
<td>Middle 41-60</td>
<td>27.7 (15.3)</td>
<td></td>
</tr>
<tr>
<td>Older 61-80</td>
<td>28.8 (15.6)</td>
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</table>

Maximum deceleration was ≥0.4g in 20.8% of participants, most of which were in the middle or older age group.
Bike path crossing results: collisions and lane departures

97.9% of all participants were not on a collision course with the bicyclist

No collisions or lane departures were observed for all participants
CONCLUSIONS

Shared lane markings resulted in more passing distance overall, especially among older drivers (61-80 years), and softer braking among novice drivers (18-25 years).

Novice and older driver performance varied significantly from the other age groups, suggesting more bicycle infrastructure research for these subgroups is warranted.

Overall, gender did not have a significant relationship with driving performance for these events.
FUTURE RESEARCH DIRECTIONS

Additional research on the comparative effectiveness of bicycle-specific treatments and infrastructure on driving performance and how this varies by age.

Further use of naturalistic bicycling data to inform simulation research and scenario and development.

Drivers <18 years old and impact of bicyclist gender.
ACKNOWLEDGMENTS

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