PUTTING PORTLAND’S CYCLISTS UNDER THE MICROSCOPE

Jennifer Dill, Ph.D.
Outline

Cycling in Portland

My Research

Bicycling behavior & route choice
Bike box evaluation
Applying theories from psychology
Cyclists per Day

Crashes and Indexed Crash Rate

Year

Bridge Bicycle Traffic

Reported Bicycle Crashes

Indexed Bicycle Crash Rate (Trend Line)

Bicycle Fatalities

Extrapolated from peak period counts

"Crash Rate" represents an indexing of annual reported crashes to daily bicycle trips across the four main bicycle bridges.

*2008 Reported Bicycle Crashes data not yet available
BikeGPS Study

Research questions
- How does the built environment influence bicycling behavior?
- What routes do cyclists take?

Phases
- Random phone survey of Portland, OR region adults
- GPS
Categories of cyclists

- Non-cyclist: 53%
- Recreational (only) cyclist: 18%
- Utilitarian: Infrequent (<1/wk year-round): 19%
- Utilitarian: Frequent (1/week year-round): 10%
Sex

- Non-cyclist
- Recreational Only
- Utilitarian Infrequent
- Utilitarian Frequent

% of men or women

- Men:
  - 46%
  - 17%
  - 22%
  - 16%

- Women:
  - 61%
  - 19%
  - 17%
  - 4%
Income

Recreation Only cycling rises with income

Less clear relationship for utilitarian cycling
## Barriers to cycling more

| Do any of the following environmental barriers keep you from biking or biking more? | Of people who want to cycle more, % of category that identified this barrier |
|---|---|---|
|  | Non-cyclist | Recreation Only | Infrequent Utilitarian |
| **Too much traffic** | 60% | 65% | 40% |
| No bike lanes or bike trails | 33% | 47% | 28% |
| No safe places to bike nearby | 33% | 38% | 18% |
| Too many hills | 28% | 36% | 32% |
| Distances to places are too great | 26% | 29% | 27% |
| Poorly maintained streets or rough surfaces | 27% | 20% | 10% |
| No interesting places to bike to | 26% | 20% | 14% |
| n (weighted) | 168 | 81 | 90 |
GPS data collection

- 164 people in 2007
  - Keep GPS for 7 days
  - Take on all bike trips (a few exceptions)
  - Not representative sample of the population
- Participant entered some data
  - Trip purpose and weather
  - If taking bike on transit
Follow up on-line survey

- Accuracy of route
- Route choice decisions
- Missing data
Trip destinations

Excludes trips involving transit
Trip distance by purpose

Excludes trips involving transit

- Exercise: 8.5 miles
- Work: 3.8 miles
- All trips: 2.8 miles
- Social/recreation: 2.1 miles
- Work related: 1.7 miles
- Personal business: 1.3 miles
- Shopping: 1.3 miles
- Dining: 1.0 miles
## Priorities for route choice

<table>
<thead>
<tr>
<th>Mean score</th>
<th>1=not at all impt, 5=very impt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
</tr>
<tr>
<td>Avoiding streets with lots of vehicle traffic</td>
<td>3.46</td>
</tr>
<tr>
<td>Minimize total distance</td>
<td>3.31</td>
</tr>
<tr>
<td>Riding in a bike lane</td>
<td>2.98</td>
</tr>
<tr>
<td>Reducing wait time due to stop signs/</td>
<td></td>
</tr>
<tr>
<td>lights</td>
<td>2.59</td>
</tr>
<tr>
<td>Riding on signed bike routes</td>
<td>2.60</td>
</tr>
<tr>
<td>Riding on an off-street bike trail/path</td>
<td>2.19</td>
</tr>
<tr>
<td>Avoiding hills</td>
<td>1.92</td>
</tr>
<tr>
<td>Number of trips (n)</td>
<td>863</td>
</tr>
</tbody>
</table>

*Excluded transit and exercise trips*
Cyclists are going longer distances to use bicycle infrastructure

<table>
<thead>
<tr>
<th>Roads without bike facilities</th>
<th>Actual Routes</th>
<th>Shortest Path Routes</th>
<th>% of network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary arterials/highways, no bike lanes</td>
<td>3%</td>
<td>15%</td>
<td>4%</td>
</tr>
<tr>
<td>Secondary arterials, no bike lanes</td>
<td>16%</td>
<td>21%</td>
<td>13%</td>
</tr>
<tr>
<td>Minor streets, no bike lanes</td>
<td>28%</td>
<td>29%</td>
<td>63%</td>
</tr>
<tr>
<td>Driveways, alleys, unimproved roads</td>
<td>1%</td>
<td>1%</td>
<td>12%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bike infrastructure</th>
<th>Actual Routes</th>
<th>Shortest Path Routes</th>
<th>% of network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary arterials/highways, with bike lanes</td>
<td>9%</td>
<td>9%</td>
<td>3%</td>
</tr>
<tr>
<td>Secondary arterials, with bike lanes</td>
<td>15%</td>
<td>13%</td>
<td>2%</td>
</tr>
<tr>
<td>Minor streets, with bike lanes</td>
<td>3%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Bike paths</td>
<td>14%</td>
<td>6%</td>
<td>2%</td>
</tr>
<tr>
<td>Bike boulevards</td>
<td>10%</td>
<td>4%</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

**Total miles of travel**: 6,131 (Actual Routes) 4,629 (Shortest Path Routes)

Excludes trips involving transit, trips with the main purpose of exercise, organized rides, and trips starting and ending at the same place.
## Comparing Men and Women

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterials without bike lanes</td>
<td>20%</td>
<td>38%</td>
<td>-18%</td>
<td>15%</td>
<td>32%</td>
<td>-16%</td>
</tr>
<tr>
<td>Roads with bike lanes</td>
<td>30%</td>
<td>25%</td>
<td>+4%</td>
<td>24%</td>
<td>22%</td>
<td>+2%</td>
</tr>
<tr>
<td>Off-street paths</td>
<td>15%</td>
<td>6%</td>
<td>+8%</td>
<td>12%</td>
<td>5%</td>
<td>+7%</td>
</tr>
<tr>
<td>Bike boulevards</td>
<td>8%</td>
<td>4%</td>
<td>+5%</td>
<td>13%</td>
<td>5%</td>
<td>+8%</td>
</tr>
<tr>
<td>Low traffic streets (including bike blvds)</td>
<td>36%</td>
<td>31%</td>
<td>+5%</td>
<td>51%</td>
<td>42%</td>
<td>+9%</td>
</tr>
<tr>
<td><strong>Total miles of travel</strong></td>
<td><strong>4,003</strong></td>
<td><strong>2,904</strong></td>
<td></td>
<td><strong>2,097</strong></td>
<td><strong>1,686</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Excludes trips involving transit, trips with the main purpose of exercise, organized rides, and trips starting and ending at the same place*
# How far would a cyclist go to...

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Percent Willing to Ride</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instead of moderate traffic street w/o bike lane...</td>
<td></td>
</tr>
<tr>
<td>Use a bike blvd for the entire trip</td>
<td>45</td>
</tr>
<tr>
<td>Use a bike lane for the entire trip</td>
<td>31</td>
</tr>
<tr>
<td>Use a bike path for the entire trip</td>
<td>57</td>
</tr>
<tr>
<td>Instead of quiet street...</td>
<td></td>
</tr>
<tr>
<td>Use a bike blvd for the entire trip</td>
<td>14</td>
</tr>
<tr>
<td>Use a bike lane for the entire trip</td>
<td>0</td>
</tr>
<tr>
<td>Use a bike path for the entire trip</td>
<td>26</td>
</tr>
<tr>
<td>Use a bike friendly bridge...</td>
<td></td>
</tr>
<tr>
<td>With separated bike facility</td>
<td>34</td>
</tr>
<tr>
<td>With bike lane</td>
<td>19.5</td>
</tr>
<tr>
<td>Avoid...</td>
<td></td>
</tr>
<tr>
<td>Each 1% additional upslope</td>
<td>27</td>
</tr>
<tr>
<td>Each additional turn per mile</td>
<td>6.5</td>
</tr>
<tr>
<td>Each additional stop sign per mile</td>
<td>1.5</td>
</tr>
<tr>
<td>Each additional traffic signal per mile</td>
<td>2.5</td>
</tr>
<tr>
<td>Avoid on 3.5 mile trip...</td>
<td></td>
</tr>
<tr>
<td>Each unsignalized major arterial crossing</td>
<td>16.5</td>
</tr>
<tr>
<td>Each unsignalized minor arterial crossing</td>
<td>2.5</td>
</tr>
<tr>
<td>Each unsignalized left turn from major arterial</td>
<td>11.5</td>
</tr>
<tr>
<td>Each unsignalized left turn from minor arterial</td>
<td>4.5</td>
</tr>
</tbody>
</table>
Evaluation of Bike Boxes at Signalized Intersections

Jennifer Dill, Ph.D.,
PSU Urban Studies & Planning
Director, Oregon Transportation Research & Education Consortium

Christopher Monsere, Ph.D., P.E.
PSU Civil & Environmental Engineering
Why Bike Boxes?

Right Hook Collision
Bike Boxes in Portland

9 - Green Bike Boxes

3 - Uncolored Bike Boxes
Methods

- Pre-Post video
  - 10 bike box (7 green, 3 uncolored)
  - 2 control
  - Analyzed 2 peak and 1 off-peak hour per location

- Intercept survey of bicyclists
  - 5 bike box intersections
  - 47% response rate (468 of 997)

- On-line survey of motorists
  - 24% response rate (717 of 3,020)
Do Users Understand the Markings?
Motorist Survey

If you approached an intersection with a red light, where should you stop your car?

- 2% in box
- 1% either
- 3% don’t know

94%

9% in box
<1% either
1% don’t know

89%
Do Users Behave as Intended?
Motorist Encroachment in the Bike Box

% of motor vehicles arriving on red signal encroaching in the bike box

- All Encroachments: 23% (Color), 28% (No Color)
- Minor: 13% (Color), 12% (No Color)
- Moderate: 5% (Color), 3% (No Color)
- Major: 10% (Color), 8% (No Color)
Comparing Encroachments of Motor Vehicles in Bike Boxes and Crosswalks

% of motor vehicles arriving on red signal encroaching

- All Intersections
  - Bike Box: 27%
  - Crosswalk: 23%
  - p = 0.134

- Color
  - Bike Box: 28%
  - Crosswalk: 25%
  - p = 0.068

- No Color
  - Bike Box: 23%
  - Crosswalk: 18%
  - p = 0.020
Location of Stopped Cyclist in Box

73% of cyclists stop ahead of motor vehicle (A or B), though only 9% in front (area A)
Are the markings improving safety?
Motor Vehicle Encroachment in Crosswalk

% of motor vehicles arriving on red signal encroaching in the crosswalk

- Control
  - Before: 10%
  - After: 13%
  - $p=0.265$

- No Color
  - Before: 6%
  - After: 19%
  - $p=0.000$

- Color
  - Before: 6%
  - After: 25%
Cyclist Encroachment in Crosswalk

% of cyclists arriving on red signal encroaching in the crosswalk

- **Control**
  - Before: 20%
  - After: 23%
  - p = 0.813

- **No Color**
  - Before: 23%
  - After: 13%
  - p = 0.046

- **Color**
  - Before: 41%
  - After: 25%
Motorist Encroachment in Bike Lane

% of right-turning motor vehicles encroaching in the bike lane

<table>
<thead>
<tr>
<th></th>
<th>Color *</th>
<th>No Color</th>
<th>Control *</th>
<th>Color *</th>
<th>No Color</th>
<th>Control</th>
<th>Color *</th>
<th>No Color *</th>
<th>Control *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to Arriving at Intersection</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>While Stopping at Red Signal</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>While Making a Right Turn</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Conflicts between motorists and cycles

No conflicts before or after at three bike box intersections and both control intersections.
Modeled reduction in conflicts

Negative binomial model, controlling for volumes of bicycles and right-turning motor vehicles
Motorist Survey

Do you think the bike box has made driving safer or more dangerous at the intersections?

<table>
<thead>
<tr>
<th></th>
<th>All motorists</th>
<th>Motorists who are not cyclists</th>
</tr>
</thead>
<tbody>
<tr>
<td>A lot safer</td>
<td>16%</td>
<td>13%</td>
</tr>
<tr>
<td>A little safer</td>
<td>36%</td>
<td>29%</td>
</tr>
<tr>
<td>No difference</td>
<td>18%</td>
<td>17%</td>
</tr>
<tr>
<td>A little more dangerous</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>A lot more dangerous</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>Don’t know</td>
<td>18%</td>
<td>27%</td>
</tr>
<tr>
<td>n</td>
<td>717</td>
<td>219</td>
</tr>
</tbody>
</table>
Motorist Survey

- Of the motorists who are not cyclists...
  - 37% think drivers drive more safely because of the bike boxes
  - 41% think the bike boxes make driving less convenient at the intersections
  - 33% feel more comfortable driving through the intersections (16% less comfortable)
  - 52% think the bike boxes make drivers more aware of bicyclists generally
  - 38% think the City should install more boxes
    - 11% think the City should remove some or all
Bicyclist Survey

Do you think the bike box has made the intersection safer for you as a cyclist?

- A lot safer: 20%
- A little safer: 57%
- No difference: 13%
- A little more dangerous: 2%
- I don't know: 8%
Does color matter?

- Two of the non-color locations have far fewer cyclists and vehicles, so conclusions from the video data are limited
  - Higher level of total motor vehicle encroachment in colored boxes (may be due to low cycling volumes)
  - Higher rate of cyclists using box as intended in colored boxes
Motorist Survey

As a driver, do you think one of the pavement marking designs is better than the other?

6%  89%
Conclusions

- Findings supporting boxes
  - Compliance and understanding is high
  - Pedestrians are benefitting from reduced crosswalk encroachment
  - Conflicts fell
  - Yielding behavior increased *(not presented here)*
  - Improved perceptions of safety

- Unclear findings
  - Increase in bike lane encroachment
  - Benefits of color
Applying theories from psych.

Theory of Planned Behavior
Stages of Change (not presented here)
Comparing two models

Psychologist’s view

Travel modeler’s view
(hybrid)
Age    Educ.    Income    Female    Pro-bike attitude

Poor bike envt, no lanes    Poor bike envt, some lanes    Good bike envt, no lanes    Good bike envt, some lanes

Perceived Behavioral Control

Intention to bicycle

Actual bicycling

Squared Multiple Correlation = 0.65
Perceived Behavioral Control

Intention to bicycle

Actual bicycling

Squared Multiple Correlation = 0.65
Squared Multiple Correlation = 0.65
Squared Multiple Correlation = 0.65
Squared Multiple Correlation = 0.65
Ongoing bicycle research at PSU

- New GPS study focusing on bicycle boulevards
  - Longitudinal panel with ~400 families
- Evaluation of cycletrack & buffered bike lanes
- Phase 2 of bike box evaluation
- Update to regional phone survey
  - Focus on categories of cyclists
- Safe routes to school
- University curriculum
Contact information

- jdill@pdx.edu
- web.pdx.edu/~jdill
- Initiative for Bicycle & Pedestrian Innovation
  www.ibpi.usp.pdx.edu
- Oregon Transportation Research & Education Consortium
  www.otrec.us