On-site observation of driver-pedestrian interaction at zebra crossings

Dr. Matus Sucha
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1. Aims

The aim of this work was to describe pedestrian-driver encounters, communication, and decision strategies at marked crossings.

Including:

- Pedestrians’ behavior before and while crossing the road at marked crossings (and when a car is approaching).

- Drivers’ behavior while approaching a marked crossing when a pedestrian is on the sidewalk or about to cross the street.

- Pedestrian-driver communication (such as eye contact, gestures, verbal expressions, and signals, such as the flashing of lights) in situations before and while crossing at marked crossings.
2. Study design

Mixed-methods study design

1. **Exploration** of pedestrians’ and drivers’ needs and conflict situations that may arise from their interaction (identification of problems): focus groups with pedestrians and drivers.

2. **Pilot study**: sites, questionnaire, observation sheet, camera recordings.

3. **Data collection/Field study**: observation (data from cameras, on-site observations, speed and density measurements), interviews (short on-site interviews with pedestrians).

4. **Exploration and generalization**: expert workshop.
2. Study design

Field study design and data

1. Four observation sites – zebra crossings in the urban area of the city of Olomouc (approx. 100,000 inhabitants)

2. 3 activities at the same time: to observe drivers’ behavior, to observe pedestrians’ behavior, and to administer interviews to pedestrians (all data connected)

3. Observation situation: a car is approaching a crossing where a pedestrian is present (waiting), approaching, or crossing the road.

4. Focus of observation:
   1. Pedestrians – their behavior before and while crossing, awareness, crossing strategies (e.g., making the driver stop), communication with drivers
   2. Drivers – their strategies while approaching a crossing (when pedestrians are present – giving priority or not), communication with pedestrians
   3. Interviews with pedestrians – their needs, perceived safety and comfort, and habits and strategies while crossing the road
2. Study design

Field study design and data

1. Date and time: data collected during December 2013-March 2014, observation times: 7.00-9.00, 12.00-13.00, 16.00-17.00. No snow, ice or wet conditions.

2. Camera recordings – of selected sites; 24 hours; car and pedestrian densities were counted.

3. Speed measurement at selected sites during observation times.

4. Altogether 1584 observations (situations observed at 4 sites).
2. Sites

Site 1: Billa supermarket

*Single crossing, narrow street with turning vehicles, no traffic lights. Average speed: 28.2 km/h. Densities (cars/pedestrians: 3358/1903, ratio 1.76)*
2. Sites

Site 2: Student cafeteria

Single crossing, narrow street, no traffic lights. Average speed: 29.9 km/h. Densities (cars/pedestrians: 3477/791, ratio 4.4)
2. Site

**Site 3: Santovka shopping gallery**

*Crossing including a tram line and bicycle lane, narrow street, no traffic lights. Average speed: 29.9 km/h. Densities (cars/pedestrians: 4672/546, ratio 8.56)*
2. Sites

Site 4: Faculty of Natural Science
Crossing including a tram line and bicycle lane, narrow street, turning vehicles, no traffic lights. Average speed: 31.2 km/h. Densities (cars/pedestrians: 4609/930, ratio 4.96)
Next steps, discussion and open questions
3. Accident data for Olomouc – 01/2010-09/2013

- No. of accidents involving pedestrians: 174
- Time: mostly before 9.00 and between 15.00 and 19.00
- Injuries and deaths: 90% with injuries, 15% involving serious injuries (27 people), 3 accidents with pedestrian fatalities (2%)
- Pedestrians: women 44%, men 26%, 20% children
- Culpability: 75% drivers; reason: failure to give priority to a pedestrian on the crossing, distraction from driving, inappropriate turning
- Type of vehicle involved: 10% trucks, 5% trams, 5% buses
- Pedestrian behavior: correct 55%, suddenly stepping into the roadway 14%
- Site: 26% on a crossing, 23% off a crossing (more than 20 m away), 9% on a light-controlled crossing with the green light on (*see next slide)
- Conditions: 70% daylight – good visibility, 25% nighttime
### 3. Accident data for Olomouc – 01/2010-09/2013

<table>
<thead>
<tr>
<th>Accident site situation</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 pedestrian entering the road at a GO signal</td>
<td>11</td>
<td>9.00%</td>
</tr>
<tr>
<td>02 pedestrian entering the road at a STOP signal</td>
<td>1</td>
<td>1.00%</td>
</tr>
<tr>
<td>03 pedestrian entering the road near a crossing (max. ca. 20 m away)</td>
<td>5</td>
<td>4.00%</td>
</tr>
<tr>
<td>04 crossing the road at a marked crossing</td>
<td>33</td>
<td>26.00%</td>
</tr>
<tr>
<td>05 crossing the road immediately before or after a vehicle pulled up at a stop</td>
<td>3</td>
<td>2.00%</td>
</tr>
<tr>
<td>06 crossing the road immediately in front of or behind a parked vehicle</td>
<td>4</td>
<td>3.00%</td>
</tr>
<tr>
<td>07 walking, standing on the sidewalk</td>
<td>5</td>
<td>4.00%</td>
</tr>
<tr>
<td>08 walking on the correct side</td>
<td>4</td>
<td>2.00%</td>
</tr>
<tr>
<td>09 walking on the wrong side</td>
<td>1</td>
<td>1.00%</td>
</tr>
<tr>
<td>10 crossing the road away from a crossing (20 or more metres away from the crossing)</td>
<td>30</td>
<td>23.00%</td>
</tr>
<tr>
<td>00 situation other than the above</td>
<td>32</td>
<td>25.00%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>129</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
4. Results

a. Speed and densities (video and radar measurement)

<table>
<thead>
<tr>
<th>Site</th>
<th>Max. speed</th>
<th>Average speed</th>
<th>No. of CARS*</th>
<th>No. of pedestrians*</th>
<th>Ratio (cars/pedestrians)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Billa</td>
<td>66.0</td>
<td>28.18</td>
<td>3358</td>
<td>1903</td>
<td>1.76</td>
</tr>
<tr>
<td>2. Cafeteria</td>
<td>53.0</td>
<td>29.88</td>
<td>3477</td>
<td>791</td>
<td>4.40</td>
</tr>
<tr>
<td>3. Santovka</td>
<td>89.0</td>
<td>29.93</td>
<td>4672</td>
<td>546</td>
<td>8.56</td>
</tr>
<tr>
<td>4. NS Faculty</td>
<td>68.0</td>
<td>31.18</td>
<td>4609</td>
<td>930</td>
<td>4.96</td>
</tr>
</tbody>
</table>

* No. of cars/pedestrians during 4 hours when observations took place (all directions)
4. Results
b. Pedestrian interviews – purpose of the trip and frequencies

Where are you going? (N= 490)
The most frequent reason for using the crossings at the given sites was going to or from school (149 respondents, i.e., 30%), followed by going to or from work (94 respondents, i.e., 19%). Other reasons given by the pedestrians included going home or to the halls of residence, going for a walk or walking for no particular purpose, and going out to engage in leisure activities.

Do you walk here regularly? (more frequently than once per week)? (N= 490)
Most of the pedestrians, specifically 384 respondents (78%), who were addressed at the given locations used the crossing regularly (more than once per week). 106 respondents (22%) used it less than weekly.
4. Results
b. Pedestrian interviews – perceived safety

Do you find it safe to cross the road here? (N= 473)
The majority of the pedestrians (287, i.e., 60%) who were interviewed found it rather safe to use the given crossings to traverse the road, while 186 respondents (40%) did not find it safe to cross the road at the crossing under study.

Perceived safety of crossings as reported by the pedestrians:
• Student cafeteria (78%)
• Billa supermarket (61%)
• Faculty of Natural Science (51%)
• Santovka shopping gallery (41%)

The most common reasons for the pedestrians finding it unsafe to cross included a poor view, heavy traffic, the speed of the passing cars, the absence of traffic lights, the absence of a traffic island on a long crossing, and experience of drivers not stopping before the crossing. A few pedestrians who responded did not find the crossing safe because there were no elements that made drivers stop or slow down, such as speed bumps.
4. Results, c. On-site observations

1. What influences drivers’ yield/go behavior? What is the role of explicit communication between drivers and pedestrians in wait/go behavior?

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>B</th>
<th>Wald</th>
<th>Sig</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car speed</td>
<td>-0.30</td>
<td>17.82</td>
<td>0.00</td>
<td>0.74</td>
</tr>
<tr>
<td>Road traffic density</td>
<td>-0.15</td>
<td>4.52</td>
<td>0.03</td>
<td>0.86</td>
</tr>
<tr>
<td>Pedestrian traffic density</td>
<td>0.12</td>
<td>2.13</td>
<td>0.14</td>
<td>1.12</td>
</tr>
<tr>
<td>The car was less than 10 metres away</td>
<td>-0.71</td>
<td>25.45</td>
<td>0.00</td>
<td>0.49</td>
</tr>
<tr>
<td>A line of cars was approaching (driving in platoon)</td>
<td>0.50</td>
<td>16.37</td>
<td>0.00</td>
<td>1.65</td>
</tr>
<tr>
<td>Child (0-12)</td>
<td>0.35</td>
<td>0.68</td>
<td>0.41</td>
<td>1.42</td>
</tr>
<tr>
<td>Male (13-25)</td>
<td>0.11</td>
<td>0.24</td>
<td>0.62</td>
<td>1.12</td>
</tr>
<tr>
<td>Female (13-25)</td>
<td>0.22</td>
<td>1.28</td>
<td>0.26</td>
<td>1.24</td>
</tr>
<tr>
<td>Female (13-25)</td>
<td>-0.04</td>
<td>0.03</td>
<td>0.85</td>
<td>0.96</td>
</tr>
<tr>
<td>Senior citizen (65+)</td>
<td>0.98</td>
<td>2.26</td>
<td>0.13</td>
<td>2.67</td>
</tr>
<tr>
<td>Group of pedestrians</td>
<td>1.04</td>
<td>24.49</td>
<td>0.00</td>
<td>2.82</td>
</tr>
<tr>
<td>The pedestrian stood waiting more than 0.5 m away from the curb</td>
<td>-1.06</td>
<td>6.64</td>
<td>0.01</td>
<td>0.35</td>
</tr>
<tr>
<td>The pedestrian used at least eye contact to give the driver a sign.</td>
<td>0.87</td>
<td>2.04</td>
<td>0.15</td>
<td>2.39</td>
</tr>
<tr>
<td>The pedestrian waited less than 5 seconds.</td>
<td>0.73</td>
<td>3.60</td>
<td>0.06</td>
<td>2.08</td>
</tr>
<tr>
<td>The pedestrian waited more than 5 seconds.</td>
<td>-1.04</td>
<td>55.33</td>
<td>0.00</td>
<td>0.35</td>
</tr>
<tr>
<td>The driver engaged in other activities while driving.</td>
<td>0.59</td>
<td>0.95</td>
<td>0.33</td>
<td>1.81</td>
</tr>
<tr>
<td>The pedestrian engaged in other activities while crossing the road.</td>
<td>-0.39</td>
<td>5.24</td>
<td>0.02</td>
<td>0.68</td>
</tr>
<tr>
<td>Invariable</td>
<td>0.00</td>
<td>0.00</td>
<td>0.99</td>
<td>1.00</td>
</tr>
</tbody>
</table>
4. Results, c. On-site observations

1. What influences drivers’ yield/go behavior? What is the role of explicit communication between drivers and pedestrians in wait/go behavior?

- The probability of a driver yielding to a pedestrian declines as the speed increases
- The probability of a driver yielding to a pedestrian declines as the traffic density increases
- A driver is more likely to yield to a pedestrian when there is a platoon of cars
- A driver is more likely to yield when a group of pedestrians is waiting/crossing
- A driver is less likely to yield if a pedestrian stands waiting more than half a meter away from the curb
- A driver is less likely to yield to a pedestrian if the latter is engaged in a different activity (such as writing a text message)

*significant
4. Results, c. On-site observations

Did the driver yield to the pedestrian?

- Stopped: 36%
- Slowed down: 17%
- No: 47%

Did the pedestrian wait before crossing the road?

- Wait until cars stop: 46%
- Wait until cars slow down: 34%
- Did not wait: 18%
- Car did not yield (pedestrian waiting): 2%
4. Results, c. On-site observations/pedestrian interviews

2. What influences pedestrians’ wait/go behavior? What is the role of explicit communication between drivers and pedestrians in wait/go behavior?

**Observations:**
- Pedestrians waited until the car came to a complete standstill (rather than slowed down) when the traffic density rates were low.
- Pedestrians waited for more than 5 seconds to cross when the traffic density rate was high.
- Pedestrians find it safer to cross the road when the traffic density is low (not confirmed for speed).
- Women feel less safe.

*significant*
4. Results, c. On-site observations/pedestrian interviews

2. What influences pedestrians’ wait/go behavior? What is the role of explicit communication between drivers and pedestrians in wait/go behavior?

Interviews:
What options do you consider when crossing a road? (whether to wait and “yield to the car” or step onto the road/crossing?) \((N= 290)\)

The most common circumstances that the pedestrians consider when crossing a road on a marked crossing (whether to wait or step onto the road) include:

- **speed of the approaching car** (197 answers)
- **distance of the car from the crossing** (164 answers)
- **traffic density** (101 answers)
- **whether there are cars approaching from both directions** (90 answers)
- **various signs given by the drivers** (waving a hand, flashing their lights, etc.) (67 answers)
- **presence of other pedestrians** (58 answers)
4. Results, c. On-site observations/pedestrian interviews

2. What influences pedestrians’ wait/go behavior? What is the role of explicit communication between drivers and pedestrians in wait/go behavior?

*Interview:*

What do you think is a sign that the driver of the oncoming vehicle will stop and let you cross? (N = 476)

The majority of the pedestrians conclude that the driver of the oncoming vehicle is about to yield to the pedestrian on the crossing on the basis of a *combination of multiple signals from the driver*. The most common single sign which the pedestrians find to be an indication of the driver giving them priority is their *slowing down* the car or bringing it to a *complete standstill*. Other indicators include *the driver’s non-verbal gestures* or making *eye contact with the driver*. Some pedestrians reported that they find the *flashing of lights* a sufficient signal from the driver. Statements referring to the pedestrians *not being able to recognise* whether the driver is giving way to them were also recorded.
4. Results, c. On-site observations/pedestrian interviews

2. What influences pedestrians’ wait/go behavior? What is the role of explicit communication between drivers and pedestrians in wait/go behavior?

*Interviews:*

How do you indicate your intention to cross a road?
The majority of the pedestrians indicate their intention to use a crossing by the way they stand by the road waiting: a pedestrian stands at the crossing or roadside waiting until it is safe to cross.

Another common indication for the driver is a person’s moving slightly forward or even stepping into the roadway. Pedestrians also try to inform the driver about their intention to cross by giving non-verbal signals, such as waving a hand and beckoning, or making eye contact with the driver. Another way of letting the driver know that a pedestrian is about to cross the road is looking around.
4. Results, c. On-site observations/pedestrian interviews

Did the driver explicitly communicate with the pedestrian?

- Yes: 61%
- No: 34%
- Other: 5%

Did the pedestrian show his/her intention to cross (and how)?

- Searching for eye contact: 84%
- Step to the road: 9%
- Waving: 4%
- No show: 1%
- Thank you to the driver: 2%
4. Results, c. On-site observations

3. Conflict situations

A conflict situation is more likely to arise if:

- cars travel at a higher speed,
- the traffic density is higher, or
- a pedestrian is distracted by a different activity when crossing.

*significant
5. Summary

1. Generally, the most relevant predictors of pedestrians’ and drivers’ behavior are:

- densities of car traffic and pedestrian flows
- car speed

2. Pedestrians – wait/go behavior and perceived safety and comfort

The majority of the pedestrians who were interviewed found it rather safe to use the marked crossings under study (60%), while 40% of the respondents do not find it safe to traverse the road at the given crossings.

46% of the pedestrians require drivers to stop before the crossing (not only slow down) for them to feel safe to cross. On the other hand, only 17% of the drivers did so (and 47% slowed down). 36% of the drivers did not yield.
5. Summary

2. Pedestrians – wait/go behavior and perceived safety and comfort

Women feel less safe.

Factors influencing pedestrians’ wait/go behavior:

• car speed
• distance of the car from the crossing
• traffic density
• whether cars are approaching from both directions
• various signals from the driver (eye contact, waving, flashing of lights)
• presence of other pedestrians
5. Summary

2. Pedestrians – wait/go behavior and perceived safety and comfort

Pedestrians indicate their intention to cross a road by:

- the way they stand at the roadside waiting
- indicating forward movement or actually stepping into the roadway
- non-verbal signals
- making eye contact
- looking around

The majority of the pedestrians (84%) were searching for eye contact with drivers, while only 34% of the drivers did so.
5. Summary

3. Drivers’ yield/go behavior

Factors influencing drivers’ yield/go behavior:

- speed (higher speed = lower willingness to yield)
- traffic density (higher density = lower willingness to yield)
- driving in a platoon = greater willingness to yield
- driver’s willingness to yield increases where there is a group of pedestrians
- pedestrian being distracted = lower willingness to yield

4. Conflict situations

The probability of conflict situations increases with:

- cars travelling at higher speeds
- higher traffic density
- pedestrians being distracted by a different activity while crossing.
Thank you for listening!

Dr. Matúš Šucha

University of Olomouc
www.trafficpsychology.cz