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

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2. Study design and sites
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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).

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)

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)*
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</td>
<td>5</td>
<td>4.00%</td>
</tr>
<tr>
<td>away)</td>
<td></td>
<td></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</td>
<td>3</td>
<td>2.00%</td>
</tr>
<tr>
<td>pulled up at a stop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>06 crossing the road immediately in front of or behind a</td>
<td>4</td>
<td>3.00%</td>
</tr>
<tr>
<td>parked vehicle</td>
<td></td>
<td></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</td>
<td>30</td>
<td>23.00%</td>
</tr>
<tr>
<td>away from the crossing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00 situation other than the above</td>
<td>32</td>
<td>25.00%</td>
</tr>
<tr>
<td>Total = 129</td>
<td></td>
<td>100%</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>1.13</td>
<td>0.14</td>
<td>1.14</td>
</tr>
<tr>
<td>The car was less than 10 metres away</td>
<td>-0.71</td>
<td>16.45</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>16.07</td>
<td>0.00</td>
<td>1.63</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>1.00</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>0.93</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>0.34</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>

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)
4. Results, c. On-site observations

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 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

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

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.