Speed choice and mental workload of elderly cyclists on e-bikes in simple and complex traffic situations:

A field experiment with instrumented bicycles
Content

• The Problem
• Research questions
• The instrumented bicycles
• The participants
• Data analysis
• Results
Index seriously injured road users
Injury and death rate by age group

Death rate

Injury rate

SWOV

27-28.11.2014

Ageing and Safe Mobility

Willem Vlakveld
Research motives

• Increasing number of (single) bicycle accidents;

• The crash rate of elderly cyclists is very high, especially when they cycle on e-bikes

• We know very little of the actual cycling behavior of elderly cyclists.
Research questions

- Do elderly cyclist adapt their speed in complex traffic situations when they cycle on an e-bike?

- If so, is speed adaptation related to mental workload?
Mental workload
(Peripheral Detection Task: attached to the helmet and thumb)

Physical workload
(heart rate on the wrist)

Cameras
(GoPro 3 Silver)

Steering angle and acceleration
(potentiometer)

Speed
(speedometer)

Data storage,
GPS, Gyroscope and 3D Acceleration

27-28.11.2014
Ageing and Safe Mobility
Willem Vlakveld
**Mental workload**
(Peripheral Detection Task: attached to the helmet and thumb)

**Data storage**
(GPS, Gyroscope and 3D Acceleration)

**Camera**
(GoPro 3)

**Steering and accelerations**
(potential)

**Speed**
(speedometer)
Mental workload
(Peripheral Detection Task: attached to the helmet and thumb)

Physical workload
(heart rate on the wrist)

Data storage,
GPS, Gyroscope
and 3D Acceleration

Cameras
(GoPro 3 Silver)

Steering angle
and acceleration
(potentiometer)

Speed
(speedometer)
Peripheral Detection Task (PDT)
Design

• Participants:
  – 30 middle aged cyclists (30-45, M = 37.7)
  – 31 older cyclists (over 65, M = 70)

• Baseline measurement
• Familiarization rides
• Test course in traffic (2x)
Course
Data

- Sample rate: 50Hz
- 69 hours of data sampling
  - 200+ million values
  - 0.7 terabyte video data

Special software was required for data analysis
Software
Video annotation

- Marking of route segments in videos with the use of signs on the road and pavement
The software tool
Examples

Traditional bicycle

E-bike
Example of special situation
Average speed per group

Distance covered from starting point in meters

Mean Speed in km/h

Area with complex traffic situations

Area with simple traffic situations

Conventional bicycle - Middle Adulthood

Conventional bicycle - Elderly

E-bike - Middle Adulthood

E-bike - Elderly
Mean speed in simple and complex traffic situations

<table>
<thead>
<tr>
<th></th>
<th>Conventional bicycle</th>
<th>E-bike</th>
<th>Conventional bicycle</th>
<th>E-bike</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple traffic</td>
<td>15.6</td>
<td>17.1</td>
<td>23.3</td>
<td>20.7</td>
</tr>
<tr>
<td>Complex traffic</td>
<td>12.7</td>
<td>14.9</td>
<td>18.3</td>
<td>16.6</td>
</tr>
</tbody>
</table>

- Red: Middle adulthood
- Blue: Elderly
## Results on PDT

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Bicycle type</th>
<th>Complexity</th>
<th>Mean RT (ms)</th>
<th>SD RT</th>
<th>HR (%)</th>
<th>SD HR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elderly</strong></td>
<td>Conventional</td>
<td>Simple</td>
<td>536.3</td>
<td>138.8</td>
<td>84.9</td>
<td>16.8</td>
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<tr>
<td>(n = 21)</td>
<td></td>
<td>Complex</td>
<td>689.8</td>
<td>170.9</td>
<td>69.3</td>
<td>21.9</td>
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<tr>
<td></td>
<td>E-bike</td>
<td>Simple</td>
<td>546.8</td>
<td>165.8</td>
<td>90.5</td>
<td>14.9</td>
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<tr>
<td></td>
<td></td>
<td>Complex</td>
<td>663.4</td>
<td>160.2</td>
<td>66.7</td>
<td>24.9</td>
</tr>
<tr>
<td><strong>Middle Adulthood</strong></td>
<td>Conventional</td>
<td>Simple</td>
<td>445.5</td>
<td>97.0</td>
<td>94.5</td>
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<tr>
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<td>Complex</td>
<td>538.7</td>
<td>128.1</td>
<td>83.9</td>
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<td>Simple</td>
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</tbody>
</table>
Main results speed

• Simple traffic situations: Elderly cyclists 3.6 kph faster on the e-bike.

• Complex traffic situations: Elderly cyclists only 1.7 kph faster on the e-bike.

• Speed patterns elderly cyclist similar to speed patterns of cyclists in middle adulthood but 2.6 kph slower.

• Elderly cyclists on e-bikes cycle as fast as cyclists in middle adulthood on a convention bicycle.
Main results mental workload

• No difference in mental workload between e-bike and conventional bicycle (both age groups)

• Mental workload is higher in complex traffic situations than in simple traffic situations

• Mental workload of elderly cyclists is higher than the mental workload of cyclists in middle adulthood.
Conclusion

The relatively high speed of the elderly cyclists on e-bikes in complex traffic situations and their relatively high mental workload in these situations could be one of the explanatory factors of the high accident risk of elderly cyclists on e-bikes.