Introduction

Summer 2017: Psychological Glare Analysis of different Headlamp Systems

1) Survey

2) Semi-Dynamic Evaluation of Perceived Glare

   *de Boers scale and Eye-Tracking System*

3) Object-Detection Distance **GFHB versus LED matrix low beam**

   *VBOX 3i and Eye-Tracking System*

4) Summary of results obtained

5) Questions and Answers
The survey asked 25 respondents to specify their age, gender and some specific questions related to driving at night:

1. Driving Distance per year
2. Mostly used lamp type
3. Satisfaction with current Headlamp system
4. Desire for better visibility
5. Frequency of night drives
6. Commonly used street type
7. Experienced Stress while driving at night
8. Level of Feeling tired while driving at night
9. Poor visibility while driving at night
10. Experienced Glare by other vehicles
11. Experienced Glare caused by street signs reflection
• 25 Respondents
• 28% female – 72% male
• Age 18 – 51 in average 29.2
• 32% required glasses to drive
• Holding a driver’s license in average since 11.2 years
• 40% of respondents to drive between 10.000 – 20.000 km /year
  (6.200 – 12.400 miles/year)
Mostly used lamp type

- HALOGEN: 48%
- XENON: 32%
- LED: 8%
- LASER: 0%
- NOT SURE: 8%
- ABSTENTION: 4%

percent
Satisfaction with the available light system

Level of satisfaction with current Headlamp system

- **Not at all**: 4%
- **Little**: 4%
- **Medium**: 28%
- **Mainly**: 64%
- **Completely**: 0%
Desire for better visibility while driving at night

- **YES**: 96%
- **NO**: 0%
- **ABSTENTION**: 4%

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Frequency of driving at night

- NEVER: 0%
- UNUSUAL: 8%
- SOMETIMES: 16%
- OFTEN: 76%
- ALWAYS: 0%

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Mainly used street type

- CITY: 27%
- COUNTRY ROAD: 59%
- HIGHWAY: 14%
Enjoying driving at night

- **ALL**: 60%
- **XENON**: 50%
- **HALOGEN**: 58.3%

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Stressed driving at night

- Abstention: 4%
- More: 44%
- Equally: 44%
- Fewer: 8%
Feeling tired while driving at night

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALWAYS</td>
<td>0%</td>
</tr>
<tr>
<td>OFTEN</td>
<td>4%</td>
</tr>
<tr>
<td>SOMETIMES</td>
<td>40%</td>
</tr>
<tr>
<td>UNUSUAL</td>
<td>48%</td>
</tr>
<tr>
<td>NEVER</td>
<td>8%</td>
</tr>
</tbody>
</table>
poor visibility / sight in the darkness

- ALWAYS: 0%
- OFTEN: 36%
- SOMETIMES: 36%
- UNUSUAL: 28%
- NEVER: 0%
Being glared by other vehicles

- ALWAYS: 0%
- OFTEN: 16%
- SOMETIMES: 80%
- UNUSUAL: 4%
- NEVER: 0%

percent

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Driving at night: Being glared by street signs

- Always: 0%
- Often: 4%
- Sometimes: 16%
- Unusual: 64%
- Never: 16%
• Mainly used head lamp type  → 48% Halogen

• Satisfaction with current HL system  → 64% mainly

• Desire for better view  → 96% yes!

• Mostly used street type (at night)  → 59% Country roads

• Feeling stressed driving at night  → 44% more than during the day

• Poor visibility driving at night  → 36% often

• Feeling being glared by other vehicles  → 76% often

• Feeling being glared by street signs  → 64% rare
2) Semi-Dynamic Glare Analysis

Prof. Dr. Dirk Meyer

Emiljano Bibleka, Marvin Dietermann

UAS-Gießen & Light Sight Safety
1. Volvo XC 60 (Xenon)
2. BMW 7er (LED)
3. BMW 5er (LED)
4. Opel Insignia (LED)
5. Volvo V90 (LED)
6. VW Touran (LED)
7. Mini Countryman (Xenon)
8. Seat Ibiza (Halogen)
• Red test cars lined up, representing the to be evaluated Head Lamp Syst

• Red cars to drive two times along track according to red flashes

• 2 x 8 and 1 x 5 (= 21) Test persons placed in white cars along runway (POS.1 – POS. 4)

• Test persons to evaluate “de Boer” amount of psychologic glare for the 8 test cars passing by twice at 70km/h, (seq1 and seq 2)

• After 2nd sequence, next 8 Test persons to enter white cars
Vehicle POS. 1

Vehicle POS. 2, 3 & 4

2) Semi-Dynamic Glare Analysis
• 2 Test runs:
  a) each performed with for the test persons unknown, different switched on Head Lamp conditions:
    Low Beam (AL), High Beam (FL) or GFHB (IL)
• Test run 1:
  2 sequences on dry runway, repeated 3 times for in total 21 Test persons
• Test run 2:
  2 sequences on wet runway, repeated 3 times for in total 21 Test persons
• One Test person in Car 1 was wearing Tobii Pro Eye Tracking Glasses
<table>
<thead>
<tr>
<th>Nr.</th>
<th>Vehicle</th>
<th>Head Lamp System</th>
<th>1. Sequence</th>
<th>2. Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Renault Twingo</td>
<td>Halogen</td>
<td>AL: Low Beam</td>
<td>FL: High Beam</td>
</tr>
<tr>
<td>2</td>
<td>Mini Countryman</td>
<td>HID AFS</td>
<td>FL: High Beam</td>
<td>AL: Low Beam</td>
</tr>
<tr>
<td>3</td>
<td>Opel Insignia</td>
<td>LED (IntelliLux MatrixLight)</td>
<td>IL: GFHB</td>
<td>AL: Low Beam</td>
</tr>
<tr>
<td>4</td>
<td>Volvo V90</td>
<td>LED ()</td>
<td>AL: Low Beam</td>
<td>IL: GFHB</td>
</tr>
<tr>
<td>5</td>
<td>Volvo XC60</td>
<td>HID (GFHB)</td>
<td>IL: GFHB</td>
<td>AL: Low Beam</td>
</tr>
<tr>
<td>6</td>
<td>BMW 5</td>
<td>LED (Selective Beam)</td>
<td>AL: Low Beam</td>
<td>IL: GFHB</td>
</tr>
<tr>
<td>7</td>
<td>BMW 7</td>
<td>Laser-Spot (Selective Beam)</td>
<td>IL: GFHB</td>
<td>AL: Low Beam</td>
</tr>
<tr>
<td>8</td>
<td>VW Touran</td>
<td>LED (Dynamic Light Assist)</td>
<td>IL: GFHB</td>
<td>AL: Low Beam</td>
</tr>
</tbody>
</table>
De Boer Scale „inverted“

- de Boer Scale from 1 to 9
- Smallest value >>> light to no glare
  Biggest Value >>> extreme glare
- Up to level 5 : acceptable
- Test person to give evaluation on form
Average = 6.22 indicating high level of satisfaction in terms of perceived glare
Average = 5.86 → 5.8 % lower than on dry runway, indicating more perceived glare.
Average = 4.15 → 33.3% lower evaluated by respondents placed in car 4

Test Car 4 at Wet Road Conditions

| de Boers Skala | AL Twingo | FL Mini | IL Insignia | AL V90 | IL XC60 | AL BMW 5 | IL BMW 7 | IL Touran | FL Twingo | AL Mini | IL V90 | AL XC60 | IL BMW 5 | AL Touran |
|----------------|----------|--------|-------------|--------|--------|---------|---------|----------|----------|--------|--------|--------|---------|---------|----------|
|                | 4.17     | 1.37   | 1.33        | 5.33   | 6.67   | 4.33    | 4.17    | 5.17     | 1.50     | 1.50   | 3.00   | 7.33   | 7.17    | 7.17    |

Lichtfunktion und Fahrzeug
Summary of average values

Mean values obtained through psychological glare

<table>
<thead>
<tr>
<th>de Boer Skala</th>
<th>Dry Road</th>
<th>Wet Road</th>
<th>Just Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye-Tracking (POS. 1)</td>
<td>6.75, 6.68</td>
<td>6.27</td>
<td>5.97</td>
</tr>
<tr>
<td>Fiat Ducato (POS. 2)</td>
<td>7.07</td>
<td>7.07</td>
<td>5.29</td>
</tr>
<tr>
<td>Ford Focus (POS. 3)</td>
<td>6.75</td>
<td>6.32</td>
<td>4.15</td>
</tr>
<tr>
<td>POS. 4</td>
<td>6.22</td>
<td>6.13</td>
<td>5.74</td>
</tr>
<tr>
<td>Female</td>
<td>6.2</td>
<td>6.2</td>
<td>5.64</td>
</tr>
<tr>
<td>male</td>
<td>6.83</td>
<td>6.17</td>
<td>5.4</td>
</tr>
<tr>
<td>18-25</td>
<td>6.1</td>
<td>6.1</td>
<td>5.4</td>
</tr>
<tr>
<td>26-40</td>
<td>6.22</td>
<td>6.22</td>
<td>5.86</td>
</tr>
<tr>
<td>40-60</td>
<td>total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Summary of findings on Glare Analysis

1. No signs of perceived glare on **Dry Road Conditions** for GFHB Head Lamp systems

2. Very little perceived glare on **Wet Road Conditions**
   Only 10% more perceived glare recorded, but still at acceptable level

3. Perpendicular to oncoming traffic positioned cars (e.g. car 4) to experience high amount of glare (55% more) since GFHB system cannot detect the car.
   Advantages or Dis-advantages need to be investigated!

4. No effects on perceived glare in terms of gender or age
• Tobii Pro X2-30 eye tracker
  • used with Tobii Pro Studio software

source: https://www.tobiipro.com/imagevault/publishedmedia/cafs3ff3rsy0of3jd44/TobiiPro_X2_Eye_Tracker_3_1.jpg
In the image, there is a graph showing eye tracking data. The x-axis represents the recording timestamp in milliseconds, ranging from -600 to 1000 ms. The y-axis represents the gaze point in millimeters, ranging from -600 to 1000 mm. The graph includes two lines:

1. Red line labeled `GazePointLeftX (ADCSmm)`
2. Green line labeled `GazePointLeftY (ADCSmm)`

The data appears to show fluctuations in the gaze points over time, with distinct sections highlighted.
• **gaze points going downwards and to the right:**
  Test Person experiences GLARE

• Test Cars 2 (Mini Countryman HID high beam) & Test Car 8 (VW Touran LED high beam) caused **biggest change in pupil diameter**

• **pupil diameter** remains small over a longer period of time after cars 2 & 8 had passed
3) Dynamic Sign Detection

Prof. Dr. Dirk Meyer
Emiljano Bibleka, Marvin Dietermann
UAS-Gießen & Light Sight Safety
• Country road trip with detection of various objects placed left and right along the road (wild boar, doll and grey colored figures made out of wood)

• Test persons to drive with GLHB Systems

• Simulation of oncoming vehicles

• In Addition test persons to wear Eye Tracking systems
- 9 Test persons to drive with:
  1. Insignia Low Beam
  2. Insignia GFHB
  3. XC60 GFHB
  4. BMW 7er GFHB
- In total 12 dummies to detect
- Detection distance to each dummy to be determined

Quelle: Google Maps
Dummy 1 (Doll, to compare with grey plywood dummies)  

Dummy 2 (grey plywood)
Dummies to be detected

Dummie 3 (dark brown Wild Boar)

Dummie 4 (with Glare caused by car at rest)
Comparison Low Beam and GFHB/ First Run

Detection Distance [m]

- DOLL (1): 18 m
- DUMMIE (2): 44 m
- WILD BOAR (3): 41 m
- DUMMIE (4) GLARE: 27 m
- DUMMIE (5): 35 m
- DUMMIE (6): 28 m
- Average: 56 m

Average GFHB: 64 m

Insignia Low Beam: 86 m

Δ = 32 m
Comparison Low Beam and GFHB/ Second Run

Detection Distance [m]

<table>
<thead>
<tr>
<th></th>
<th>DOLL (1)</th>
<th>DUMMIE (2)</th>
<th>WILD BOAR (3)</th>
<th>DUMMIE (4) GLARE</th>
<th>DUMMIE (5)</th>
<th>DUMMIE (6)</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Beam</td>
<td>13</td>
<td>69</td>
<td>70</td>
<td>93</td>
<td>68</td>
<td>82</td>
<td>103</td>
</tr>
<tr>
<td>GFHB</td>
<td>28</td>
<td>41</td>
<td>82</td>
<td>35</td>
<td>35</td>
<td>59</td>
<td>35</td>
</tr>
</tbody>
</table>

$\Delta = 44$ m
• Low Beam only is not enough to allow for necessary visibility at >70km/h
  → Too many accidents occur at night due to poor visibility

• Glare-free high beam does significantly increase ride comfort and safety
  → Oncoming traffic does not experience noticeable higher amount of glare
  → On average visibility is twice as high using GFHighB

• Potential customers need to be better informed about new headlamp technologies
  → For example, test drive cars at night, dealers to start using Virtual Reality Tools!
Prof. Dr. Dirk Meyer

Lars Weck

UAS-Gießen & Light Sight Safety
test track 1 „way up“
test track 2: „way back“
• task:
  • 12 objects have to be detected by the driver, wearing the eye tracking glasses
  • velocity of the test vehicle has to be 60-80 km/h
• Tobii Pro Glasses 2
  • used with Tobii Pro Studio software

source:
https://www.tobiipro.com/imagevault/publishedmedia/9of1ntsqe84c0p4f2qk/TobiiPro_Glasses_2_Eye_Tracker_side_3_1.jpg
About the eyetracking system

- Tobii Pro X2-30 eye tracker
  - used with Tobii Pro Studio software

source: https://www.tobiipro.com/imagevault/publishedmedia/cafs3ff3rsy0of3jdz44/TobiiPro_X2_Eye_Tracker_3_1.jpg
Eyetracking Video Volvo XC60 HID Low Beam

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Fixation point X-axis

Fixation point x-axis [mm]

recording timestamp [ms]
Fixation point y-axis recording timestamp [ms]

fixation point y-axis [mm]

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• using GFHB systems the visibility of objects beyond the road limits is significantly improved
• drivers do look over the side limits of the road while using GFHB systems
• With GFHB systems being switched off, drivers focus only within the limits of the road or the limits of the Low Beam beam pattern respectively
• Psychological signs of glare noticed with Eye Tracking System (oncoming traffic using Low Beam)
• More detailed Analysis on Psychological Glare possible with Eye-Tracking System
Thank you

Q & A...?