# Discomfort of bright DRL in the transition phase

**Results of a field test experiment and interpretation of daytime running lights (DRL)**

**A study from TU Darmstadt and Valeo**

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TECHNISCHE
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DARMSTADT

Adaptive Lichttechnische Systeme
und Visuelle Verarbeitung

In cooperation with

Valeo

SMART TECHNOLOGY
FOR SMARTER MOBILITY

# Motivation
## Brightness of daytime running lights

**Origin Question:**

- Is it sufficient for the recognizability of vehicles to drive with daytime running lights below 400cd even at illuminance levels below 1.000lx?

- Does glare occur in these cases?

**Interesting side result:**

- Lower illuminance intensities (<400cd) seems to be sufficiently visible and bright even above 1000lx
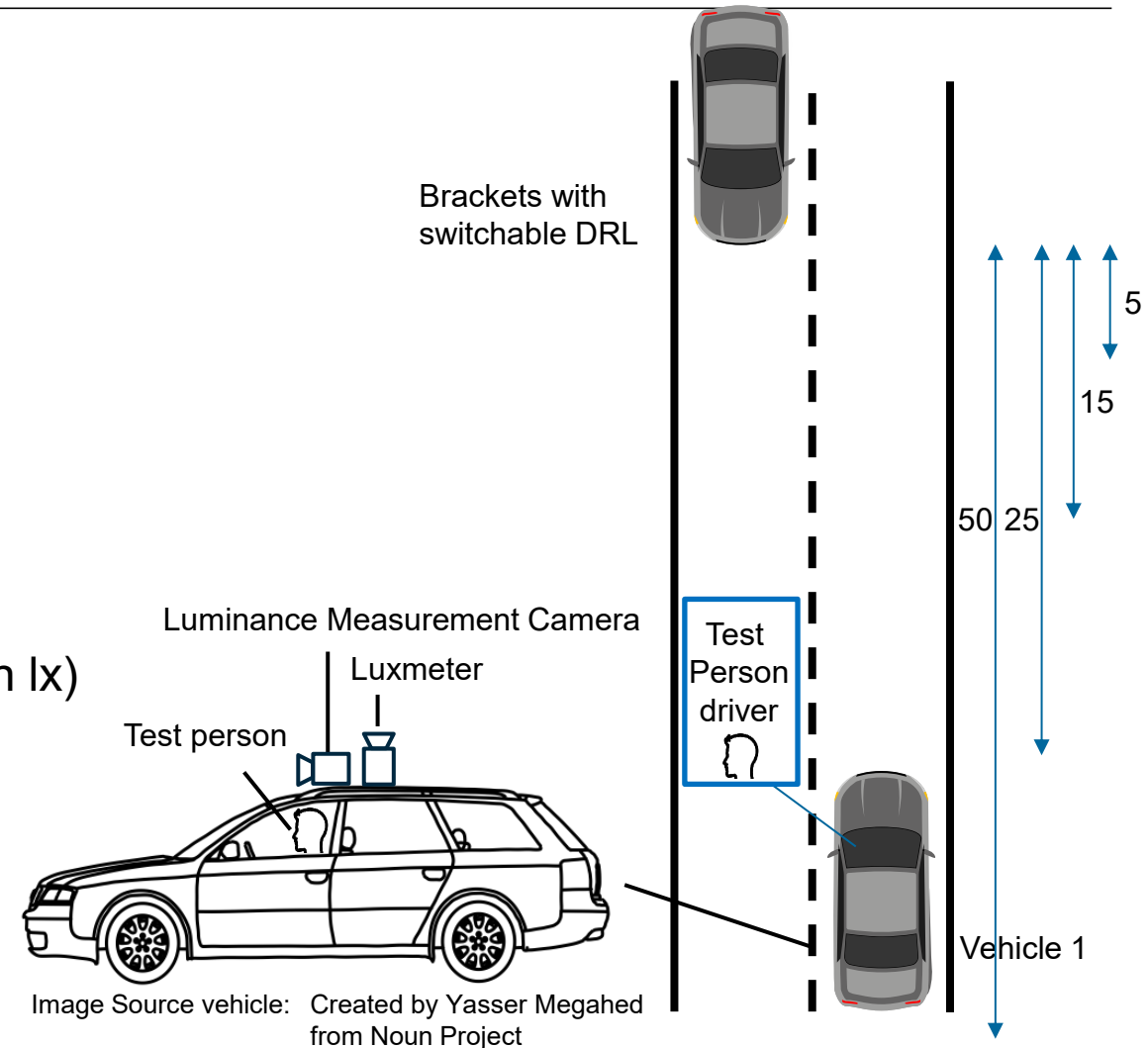
→ Possibilities of adaptive dimming?
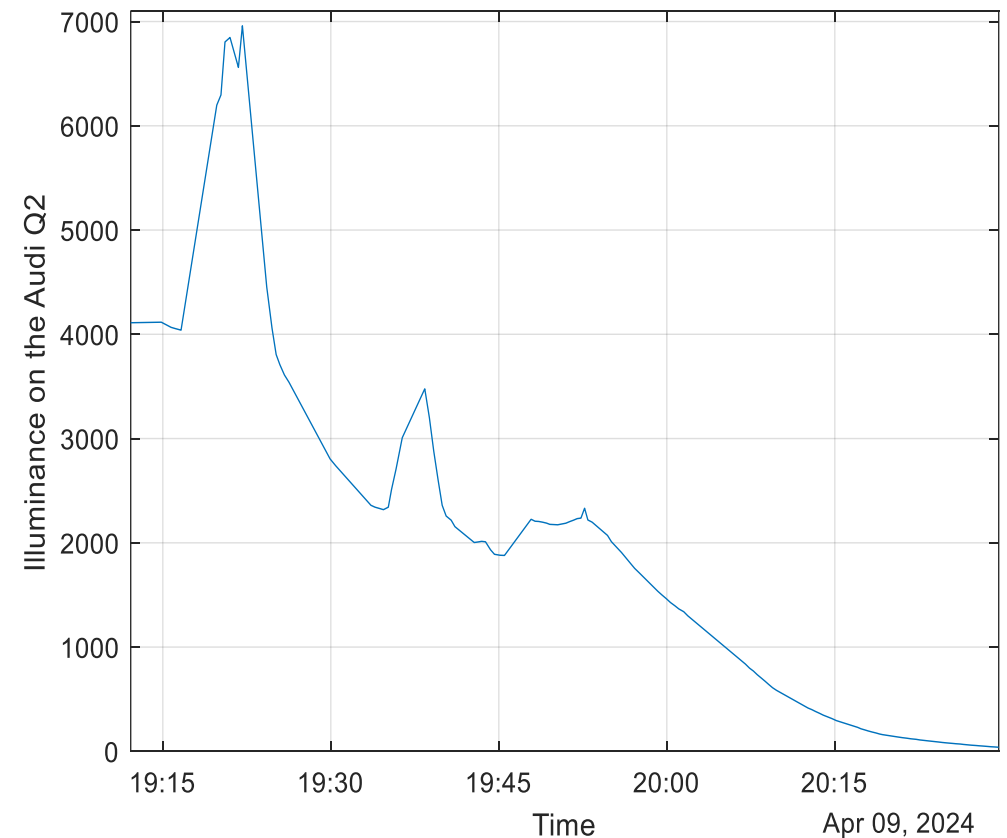
# Study concept - experiments on adaptive DRL
## Experiment settings

**Testsetup:**

- Static test
  - On the airfield near Darmstadt
  - Daytime to nighttime (sunset transition)
    - Natural variation of ambient brightness
  - Situations
    1. Oncoming traffic situations
       - Pedestrians and Cardrivers
       - Rating at 50m, 25m, 15m, 5m
  - Dimming level dependent on ambient light illuminance (in lx)

- Aims:
  - Minimum brightness of DRLs for visibility
  - Maximum brightness of DRLs to avoid glare

Brackets with switchable DRL

5

15

50 25

Luminance Measurement Camera

Test Person driver

Luxmeter

Test person

Image Source vehicle: Created by Yasser Megahed from Noun Project

Vehicle 1

# Experiments on adaptive DRL and PL
## Experiment settings

- **The test takes place at the west end of the August Euler airfield near to Darmstadt**
  - The test setup exists 3 times with
    - Mokka lamps
    - Q2 lamps
    - Golf lamps
    - Different dimming levels:

|  | luminous intensity at HV point in cd | | | | | |
|---|---|---|---|---|---|---|
|  | Opel Mokka | | Audi Q2 | | VW Golf | |
| Ambient illuminance (lx) | min | max | min | max | min | max |
| >5000 | 232 | 464 | 247 | 565 | 251 | 596 |
| >2500 | 116 | 348 | 159 | 300 | 125 | 311 |
| >1200 | 81 | 174 | 88 | 177 | 94 | 173 |
| >500 | 46 | 186 | 35 | 124 | 63 | 141 |
| >280 | 23 | 81 | 18 | 106 | 47 | 125 |
| >100 | 11 | 70 | 18 | 106 | 31 | 110 |

  - Ground markings show the distances from 5 to 75 meters at the distances shown
  - 56 participants evaluate at different distances and times



Image Source: www.google.com/maps

■ **Questions for the test subjects:**

- Question 1: Are the lights on or off?
- Question 2: Are you glared? – Yes or No Question
  - If Question 2 is answered with "yes": Question 2a: Rate the glare on the De Boer-Skala

**De Boer-Skala** (**English**/German):

1. **Unbearable**/Unerträglich
2. 
3. **Disturbing**/Störend
4. 
5. **Just Acceptable**/Gerade noch akzeptabel
6. 
7. **Satisfactory**/Akzeptabel
8. 
9. **Just Noticeable**/Unmerklich

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- Task:

  - To rule out the possibility of test subjects seeing the moment the light switches on, particularly in question 1, they should look away and cover the lights with their hand:
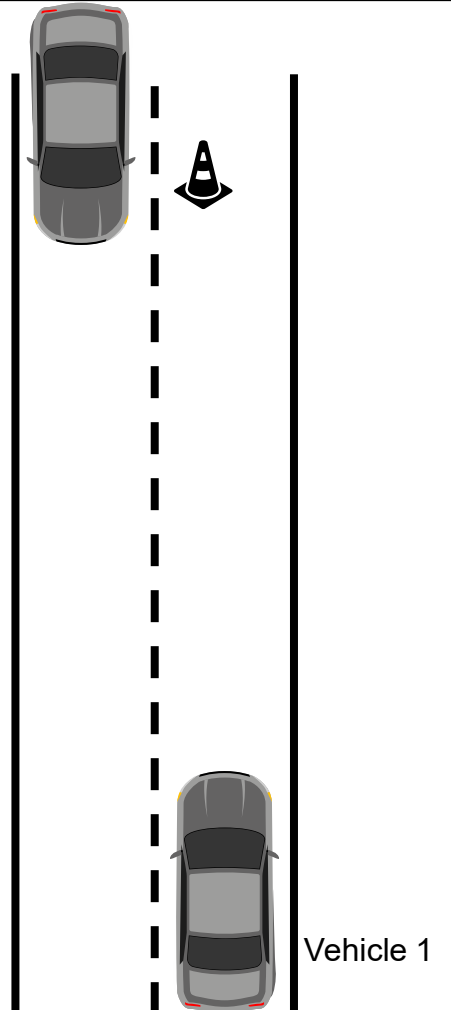
    - **Cardriver:**

      1. Command 1: Looking to the right towards the passenger seat, hand in front of the temple

      2. Command 2: Turn head to the left until facing a cone. Answer question 1.

      3. Command 3: Look at the vehicle, rate the glare



Brackets with switchable DRL
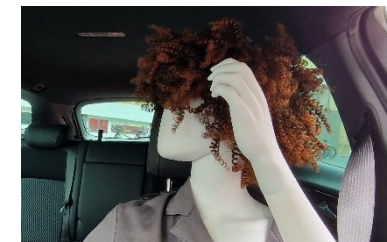
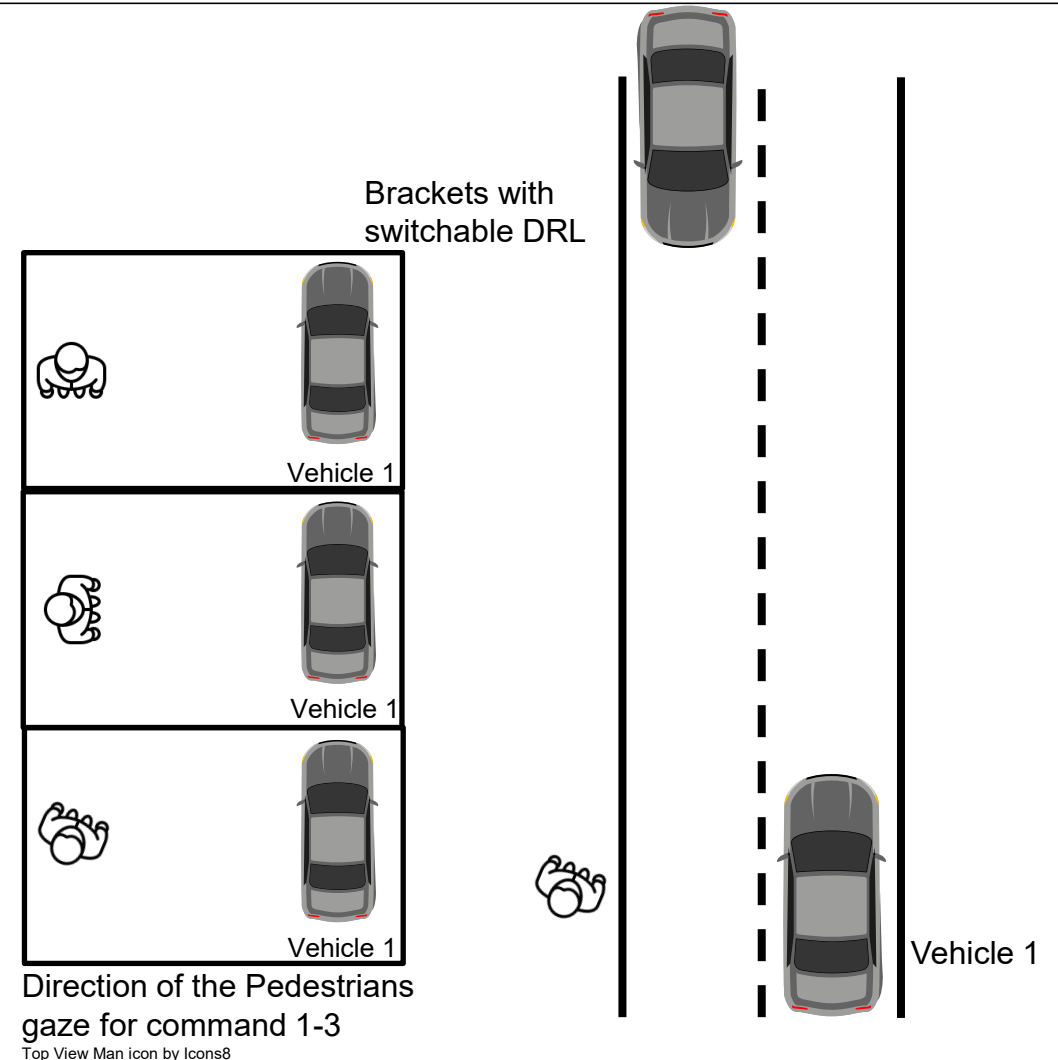Direction of the driver's gaze for command 1-3

Vehicle 1

# Study concept - Exeriments on adaptive DRL
## Experiment Tasks/Questions for test subjects

- ■ Task:

  - ■ **Pedestrian:**

    - ■ For pedestrians, the situation is intensified to simulate visibility in cross traffic.

    1. Command 1: Viewing direction opposite the lamps to be analysed

    2. Command 2: Turn body to the left until facing the Cardriver. Answer question 1.

    3. Command 3: Turn body and look at the vehicle, rate the glare

Brackets with switchable DRL

Vehicle 1

Vehicle 1

Vehicle 1

Vehicle 1

Direction of the Pedestrians gaze for command 1-3

Top View Man icon by Icons8

# Data Analyses
## Visibility car drivers (Seen)

- The answers to the question of whether the luminaires were seen are compared (**no distance differentiation**)



Cardriver
Oncoming for 5 to 50m
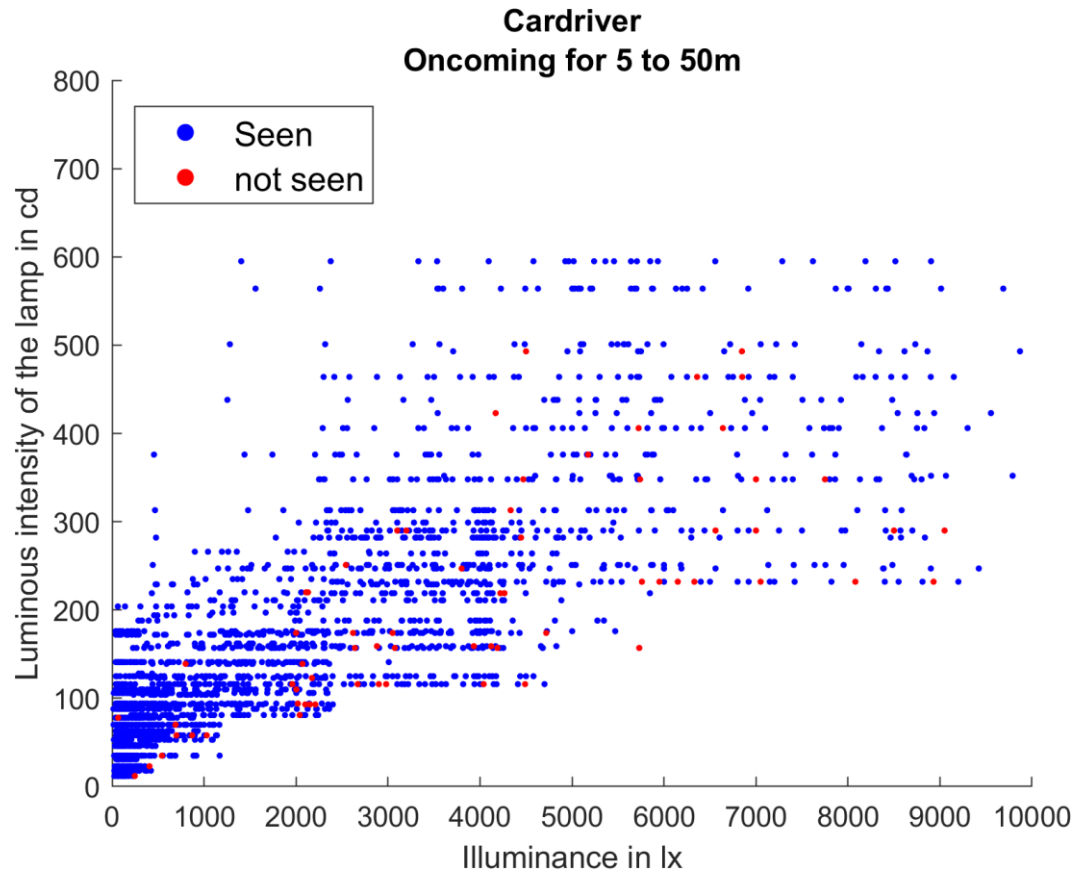
- Yes or no answers
- Straight line of vision
- Light in the corner of the eye, but still in central vision
- The majority of participants recognize that there is a vehicle

→ **The vehicles are very recognisable even at low intensities**

→ At which points was detection limited?
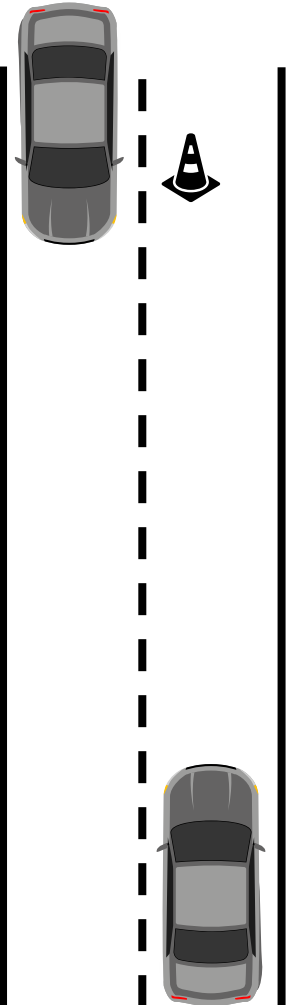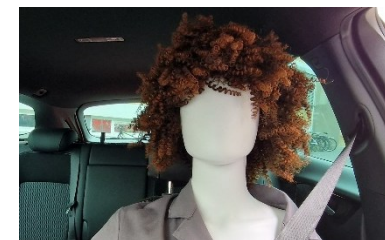
- ▪ At which points was detection limited?



Fahrzeug: Opel Mokka
Distance: 5 m
Movement: CarDriver
Direction: Oncoming

- The majority of Not Seen responses are caused by the distance of 5 m:
  - Very high viewing angle, clearly > 10°
  - Except for one point (220cd, 2 participants), the majority still saw the lights in all points



Source: https://en.wikipedia.org/wiki/Photoreceptor_cell
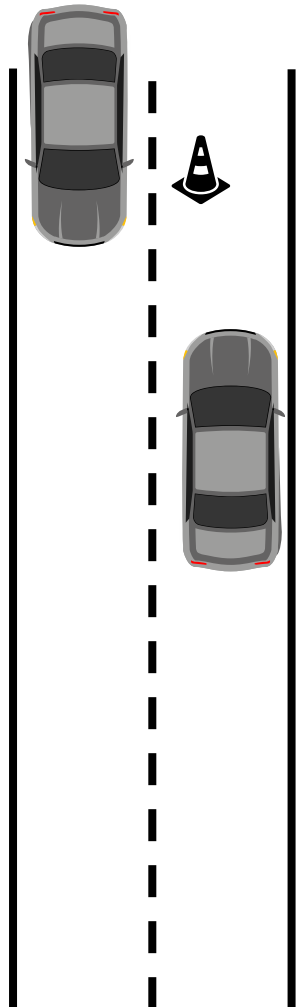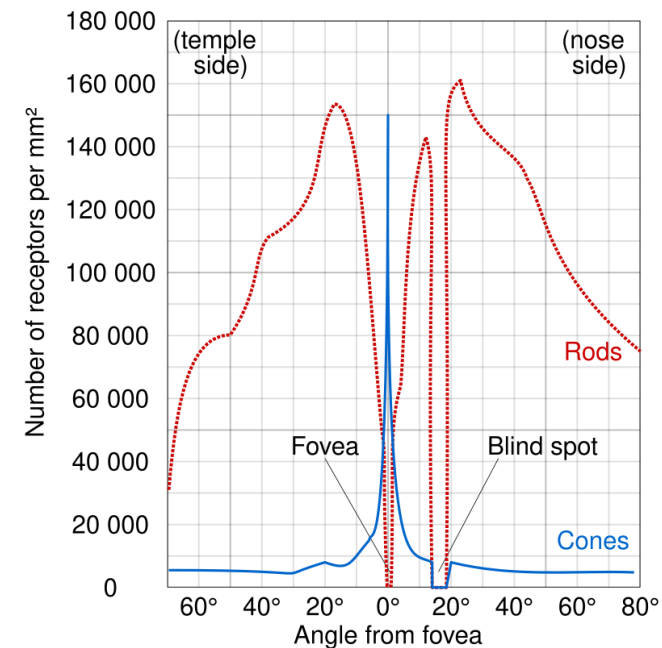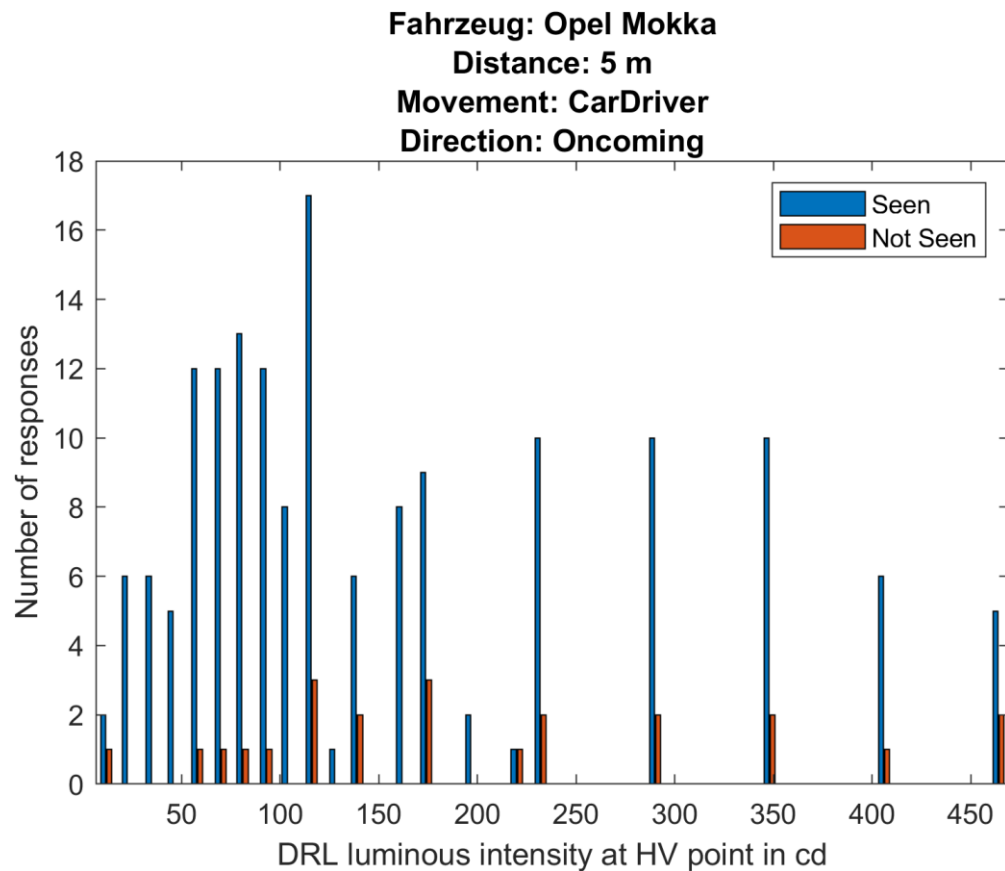
# Data Analyses
## Visibility car drivers (Seen) - Calculated for all distances ≥ 15m
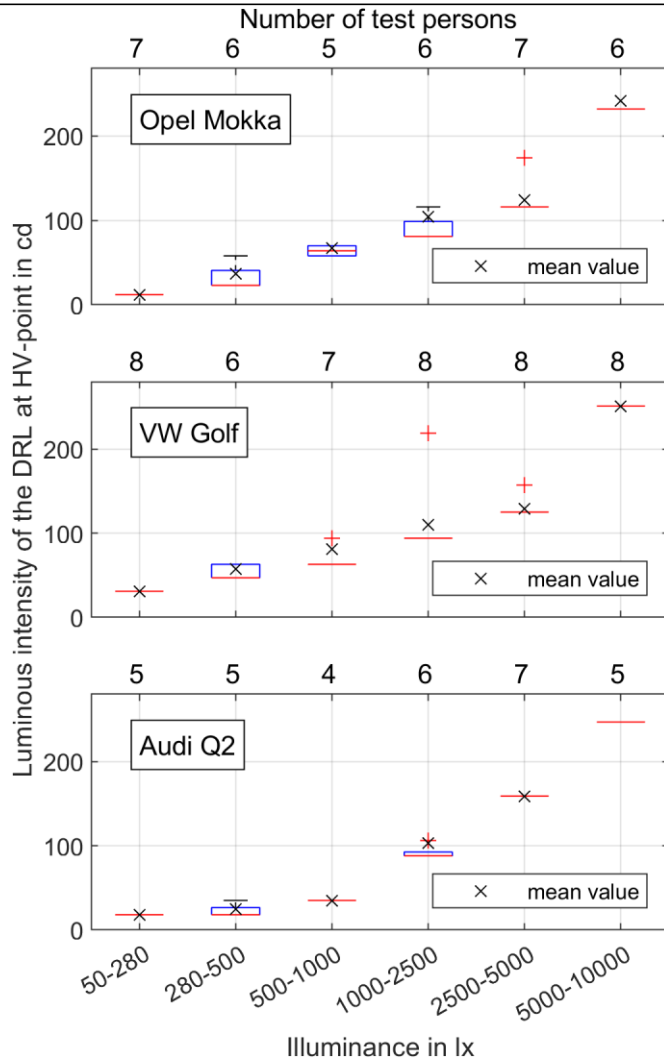


- **Lowest value of the visibility rating of the interviewed test persons**
  - Categorization into ambient illuminance ranges
    - 50 lx-280 lx, 280 lx – 500lx, 500 lx – 1000 lx, 1000 lx – 1500 lx, …
  - Only the values presented to the test subjects are included
  - The required intensity decreases with decreasing ambient lighting
  - At values between 5000 lx and 10000 lx, less than 300cd are required at the H-V point
  - Between 1000 lx and 5000 lx - the needed luminous intensity of DRL even far below 200 cd
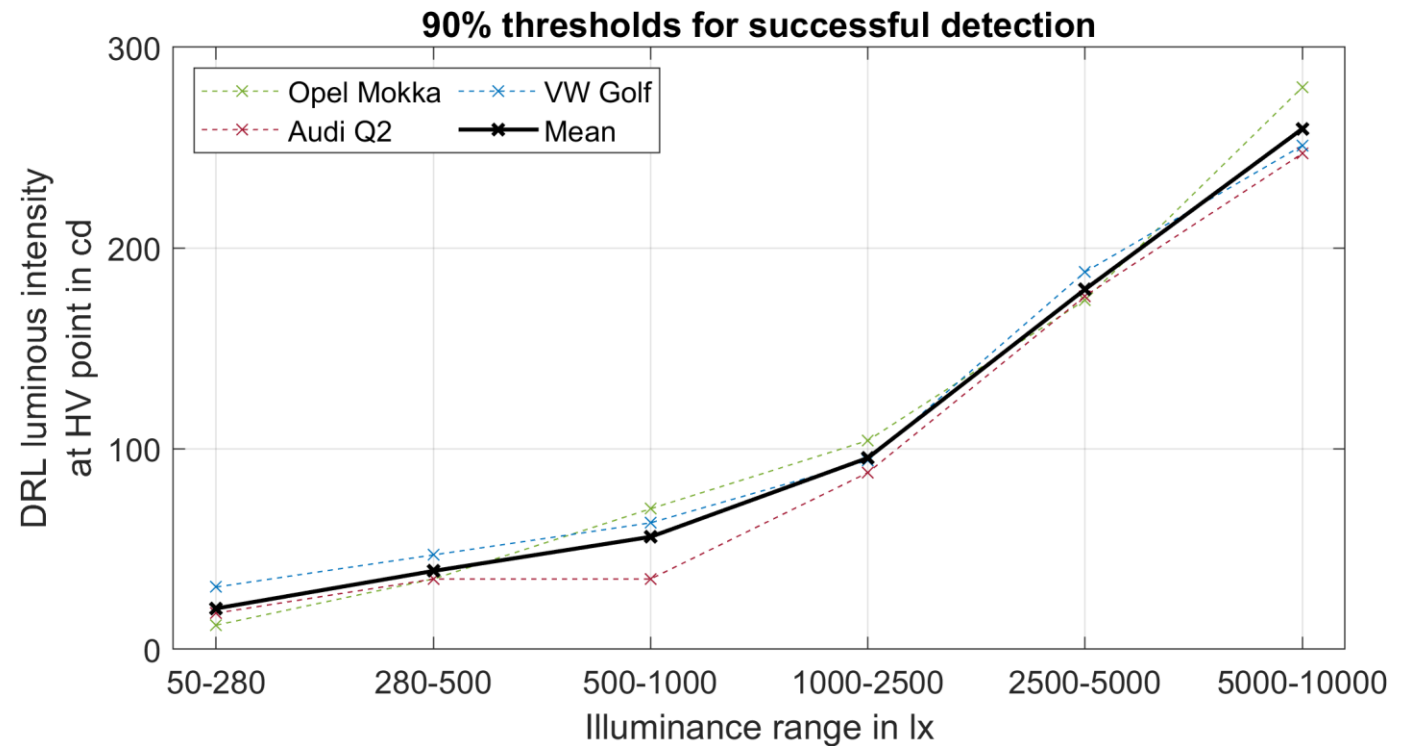
# Data Analyses
## Visibility car drivers (Seen) Distances ≥ 15m
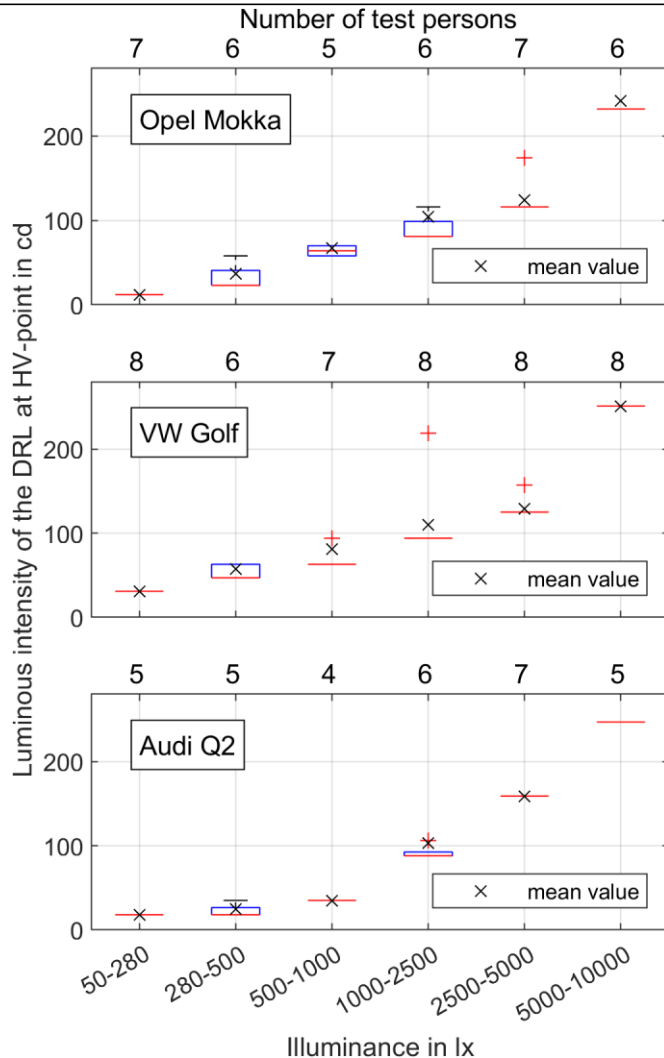


- Determination of lower limit
  - Calculation: At what intensity can 90% of people detect the DRL?
  - Average of all functions gives **lower** limit

# Data Analyses
## Car driver - <span style="color:red">Glare:</span> Mokka
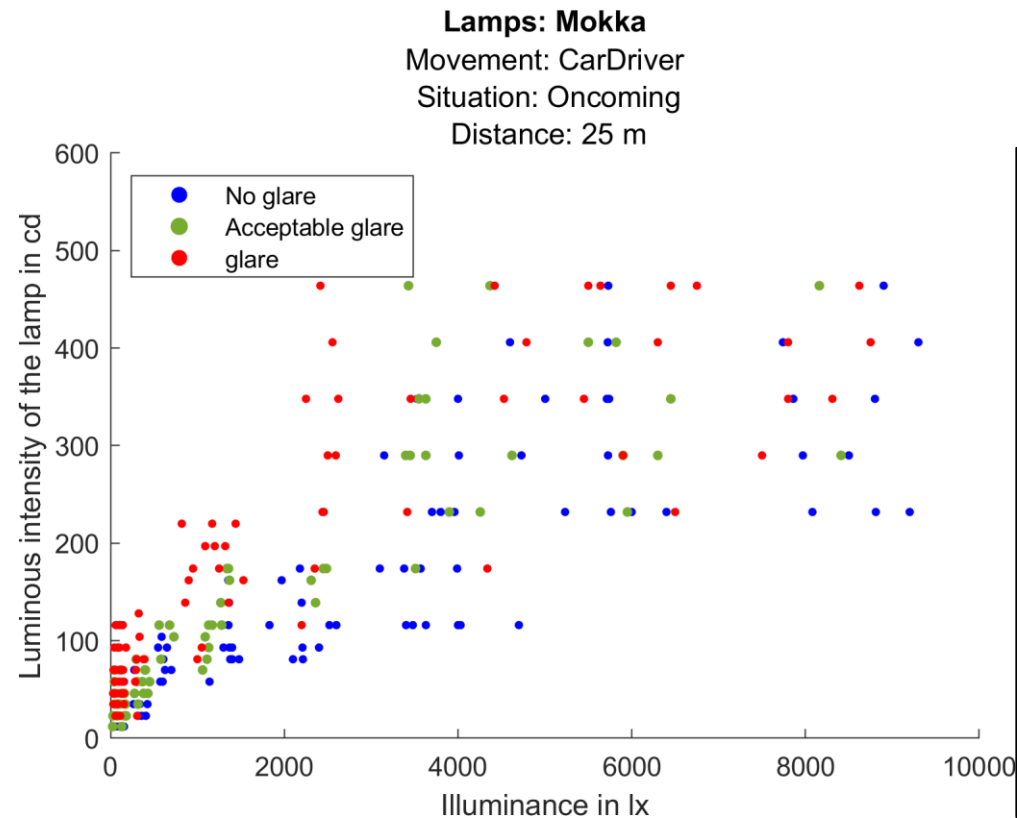
- As an example, let's look at the Mokka at 25 metres
  - Pedestrians and drivers assess the glare
    - direct view to the DRL-lights
  - Goal: Daytime running lights should be catching but not distracting
    - → Three categories
      - No glare
      - Acceptable glare
      - Glare

      } DRL in this area

- Consideration of unpleasant glare = glare worse than acceptable
  - Calculation S-curve according to Linschoten[1]

**Lamps: Mokka**
Movement: CarDriver
Situation: Oncoming
Distance: 25 m



De Boer-Skala

1. **<span style="color:red">Unbearable</span>**
2. <span style="color:red"></span>
3. **<span style="color:red">Disturbing</span>**
4.
5. **<span style="color:red">Just Acceptable</span>**
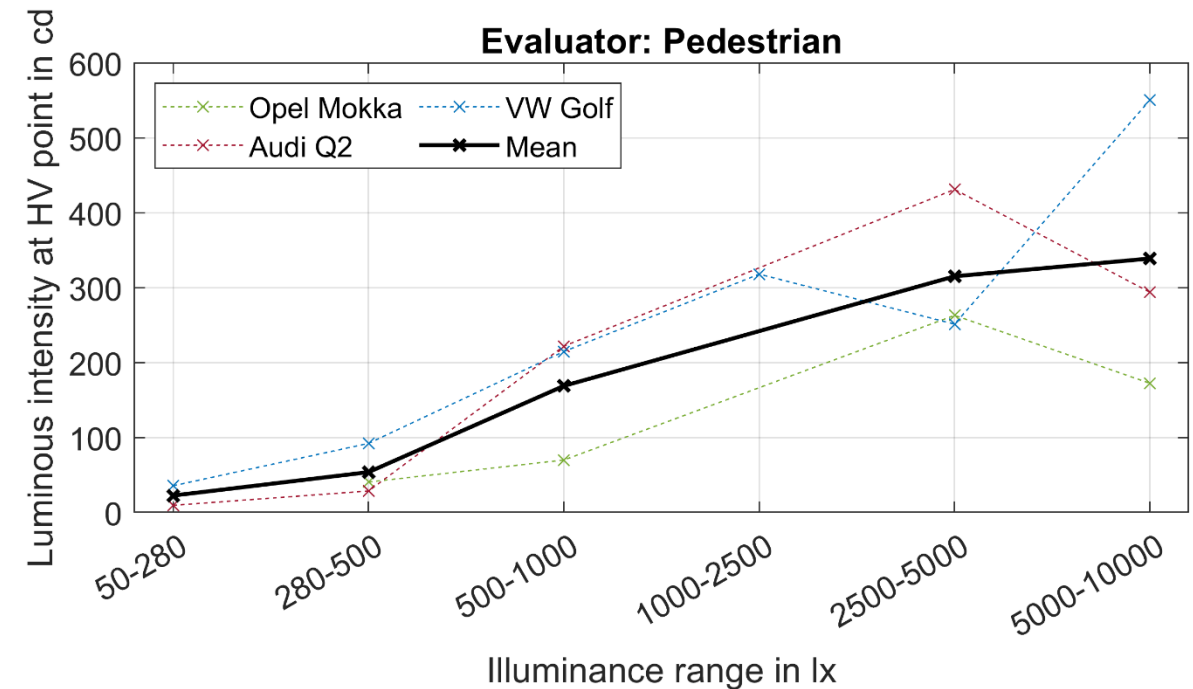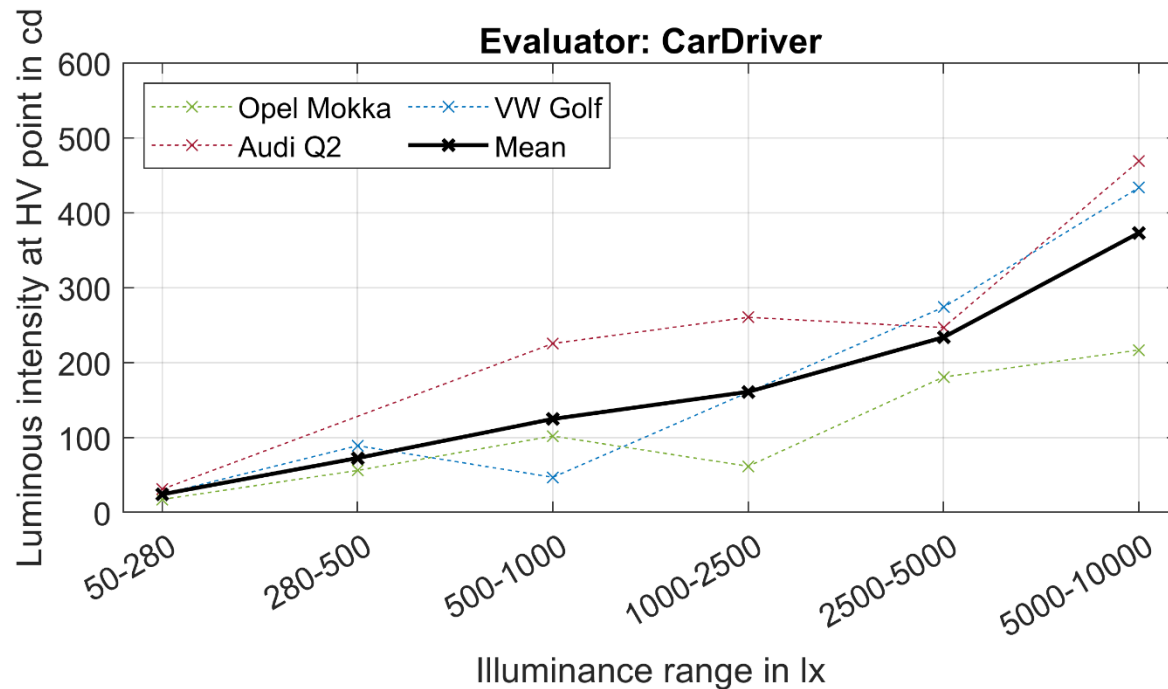6.
7. **<span style="color:green">Acceptable</span>**
8.
9. **<span style="color:green">Just Noticeable</span>**

**<span style="color:blue">No Glare</span>**

# Data Analyses
## Glare: Acceptable Glare – All Distances

- Visualization of the calculated optima (90% not glared), for all distances
  - As the ambient lighting decreases, the glare threshold shifts to lower dim values for the daytime running lights
  - Average of all functions gives **upper** limit

# Conclusion
## Glare: Acceptable Glare – All Distances

- **The overall thresholds result from the upper and lower thresholds**
  - With the modern DRL tested, lower values than 400cd seem to be sufficient even above 1.000 lx
  - This study has shown that there is a clearly recognizable trend that glare occurs as the illuminance of the surroundings <u>decreases</u>
  - The study carried out looked at many influencing parameters. As a result, only a few test subject responses were obtained at some points. Here it is advisable to generate further data sets in follow-up studies



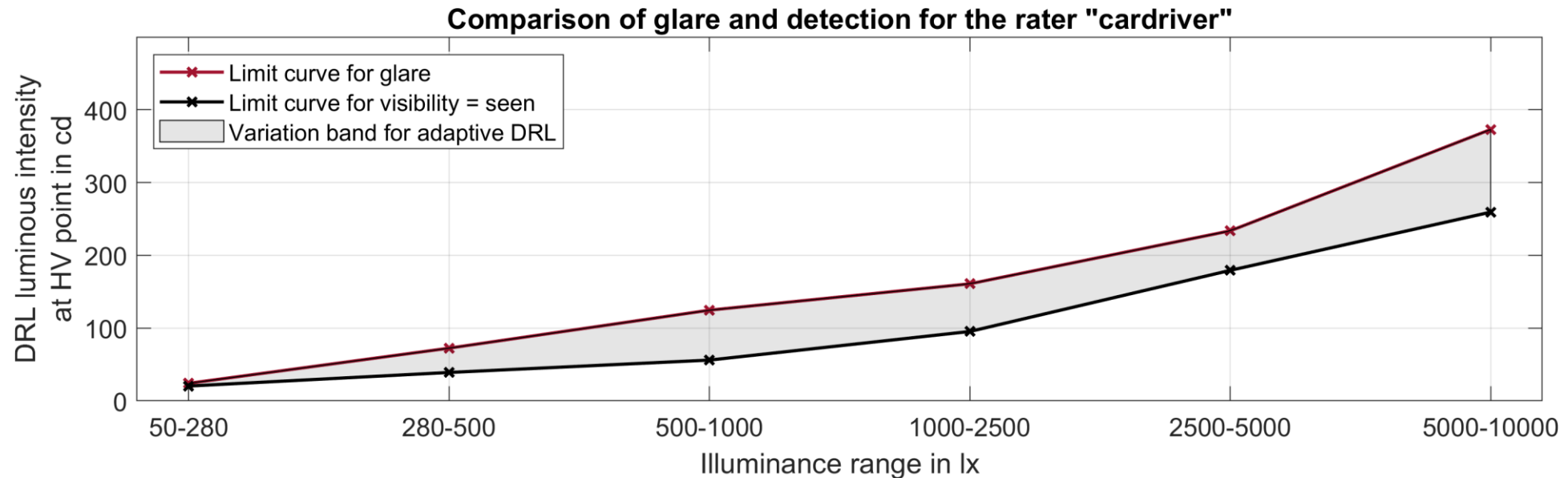Comparison of glare and detection for the rater "cardriver"
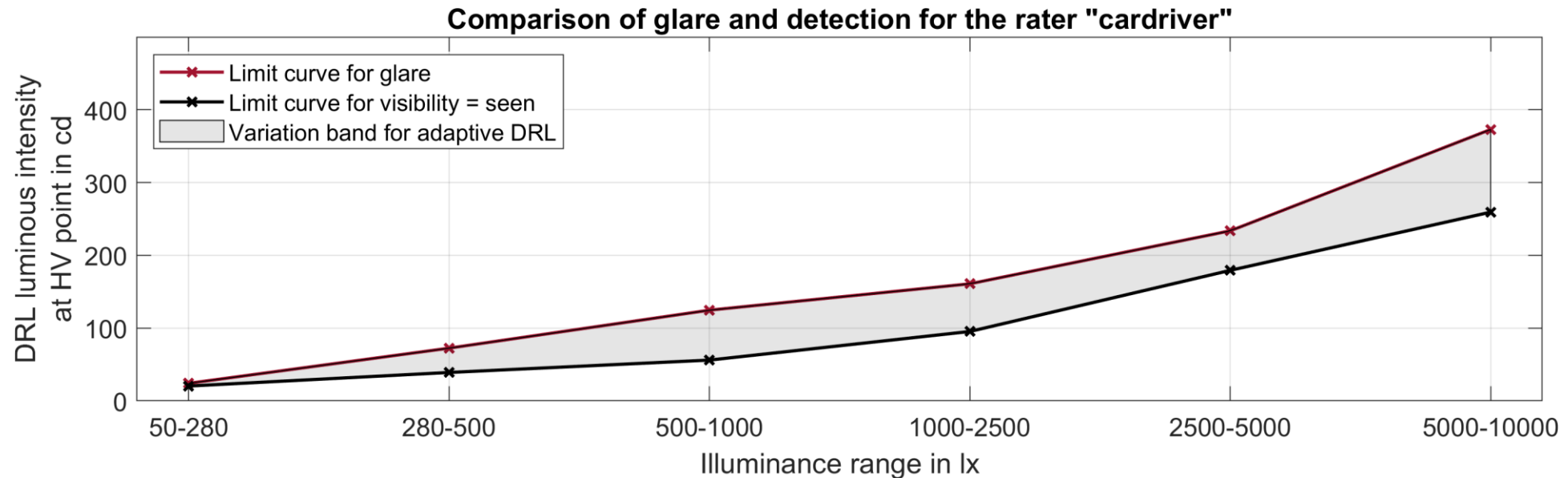
# Conclusion
## What could be done?

- **Over 1.000lx illuminance level:**
  - Adaptive adjustment of the daytime running lights by dimming
  - Reduction of glare at the beginning of dusk, bad weather, etc.

- **Under 1.000lx illuminance level:**
  - Other studies (GTB/TU Darmstadt) have shown that a longer use of DRL would be possible, e.g. up to 500lx
  - With adaptive dimmable DRLs, good visibility without glare can be achieved



**Comparison of glare and detection for the rater "cardriver"**

Legend:
- Limit curve for glare
- Limit curve for visibility = seen
- Variation band for adaptive DRL

Y-axis: DRL luminous intensity at HV point in cd
X-axis: Illuminance range in lx (50-280, 280-500, 500-1000, 1000-2500, 2500-5000, 5000-10000)

# Thank you for your attention!

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# Bibliography

[1]  Linschoten, M.R., Harvey, L.O., Eller, P.M. et al. Fast and accurate measurement of taste and smell thresholds using a maximum-likelihood adaptive staircase procedure. Perception & Psychophysics 63, 1330–1347 (2001). https://doi.org/10.3758/BF03194546