Light.Sight.Safety

Labeling
of
Autonomous Driving Vehicles

(Phase 1)

Light
Sight
Safety
a CLEPA initiative

Why? - Reason for the Study

- Autonomous driving vehicles and human road users will share roads → autonomous driving vehicle can not communicate like human → problematic situations leading to confusion will occur
- Possible Solution: labeling of autonomous driving vehicles
- Phase 1: discovering useful positions for labeling

- Procedure
  1. Trial:
     Participants are asked to look at different pictures (showing vehicles in different situations / perpectives)
     → eye tracking system is used to record their eye movement

  2. Questionaire:
     Participants are asked to mark where they would expect a label for an autonomous vehicle

  3. Evaluation of eye movement:
     Analysis of the eye tracking data

How? - Content of the Study

Preparation

- Analysis of the problem
- Development of a test procedure
- Creation and selection of pictures
- Examination of the test procedure with a pretest
- Recruitment of trial participants

Trial

- 106 participants
- 6 test days
- 9-77 years old
- 24 % female
- Participants look at 5 picture types (vehicles in different perspectives / traffic situations)
- Eye tracking system records eye movement
- 2 kinds of test:
  1) WHERE do participants look at vehicles if they have no additional information
  2) WHERE do participants look at vehicles when they are falsely told that the vehicles shown are autonomous AND already labeled (in the test just a few vehicles are labeled)
- Questionnaire: Participants mark where they would expect a label for an autonomous driving vehicle

Evaluation

- Preparation of the eye tracking data
- Defining Method of Evaluation by areas of interest, hit ratio, entry time and dwell time
- Evaluation of each picture and the questionnaire
- Summary and visualization of the results
- Video documentation („making of" and Tesla simulation)

What? - Outcome of the Study

Favourable positions for labeling

Conclusions - Summary of the Study

-The eye movement data acquired during the trial was evaluated in terms of hit ratio, entry time and dwell time to determine areas of interest (AoIs)

- Data from the questionnaire did not always correspond to the eye tracking data

- Differences in vehicle type or color had only minor influence on the eye movement

- Day and night time pictures showed different perceptions of AoIs

Conclusions - Summary of the Study

- Gender and age of trial participants revealed very little differences in Perception of AoIs

- Asked to look for special labeling on pictures that did not incorporate any kind of additional labeling resulted in longer dwell times on preferred AoIs (fake test)

- Recognition of autonomous labeling in pictures where these were present could be determined

- **Suitable positions for labeling autonomous vehicles were found**

Partners

Study performed

between February 2018 and December 2018

on behalf of

by

Technische Hochschule Mittelhessen

Light.Sight.Safety

a coalition of lighting suppliers

endeavouring to

- creating more awareness and understanding of the safety, comfort and environmental aspects of good quality automotive lighting amongst stakeholders at both public authorities and vehicle manufacturers
- sharing findings as common positions

Investigation to identify the ideal position to label autonomous driving vehicles at the UAS Gießen

Procedure and presentation of results

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2. What did we try to figure out?

3. Eye Tracking Investigation

4. What did the participants see?

5. Evaluation

   →Questionnaire
   →Eye movements

6. Conclusion

7. What's next?

What did we do?

- Examined and interviewed **106 participants** on six test days

- 9 to 77 years old

- 24 % female

- Used eye Tracking System
  → Showed in sum 34 pictures of 5 categories

- Display time per picture → 4 or 5 seconds

- After Eye Tracking test
  → Questionnaire detailing: **Where** would participants expect a labelling

What did we try to figure out?

- Are there differences in how people look at distinctive vehicle models or vehicle categories?

- Does the vehicle color, lighting condition or perspective influence the eye movement?

- Are there differences if the vehicle is photographed stationary or if it's involved in traffic situations?

- Does an falsely told information (that shown vehicles are already labelled; in real they are not) influence the eye movement?

Eye Tracking Investigation
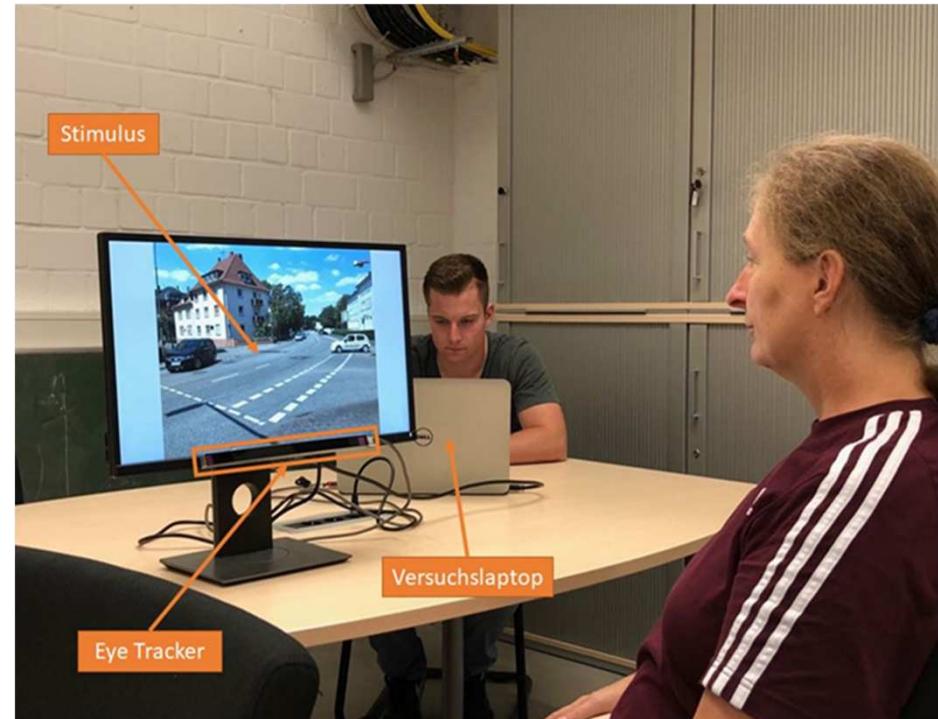
- Separated into two parts

Control Test:

WHERE do participants look at vehicles if they have no additional information?

Fake Test:

WHERE do people look at vehicles when they are falsely told that the shown vehicles are autonomous AND already labeled?

→**Target: Find intuitive positions for a labeling!**

What did the participants see?

Vielen Dank, dass Sie an diesem Versuch teilnehmen.

Im folgenden werden Ihnen einige Bilder präsentiert.

Picture type 1

- 3 kinds of vehicles
  → SUVs and limousines

- Only Black vehicles in different perspectives
  → front view, rear view, side view

- Vehicles fill out the picture area to a maximum

- Neutral background

Picture type 1

Picture type 2

- 4 kinds of vehicles
  - → Coupés, limousines, small cars, cabriolets

- Variation of parameters:
  - → different perspectives
  - → different colors
  - → different background
  - → Vehicles do not fill out the picture area
    to a maximum anymore

Picture type 2

Picture type 3

- Vehicles in different traffic situations

- Vehicles are not labelled

- Pictures are taken in the daytime

Picture type 3

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Picture type 4

- Vehicles in different traffic situations

- Vehicles are labelled

- Pictures are taken in the daytime and night time

label

label

Picture type 4

Picture type 5

- Interim pictures

   → used to keep the participants interested
   → to analyse how people perceive pictures in general

Picture type 5
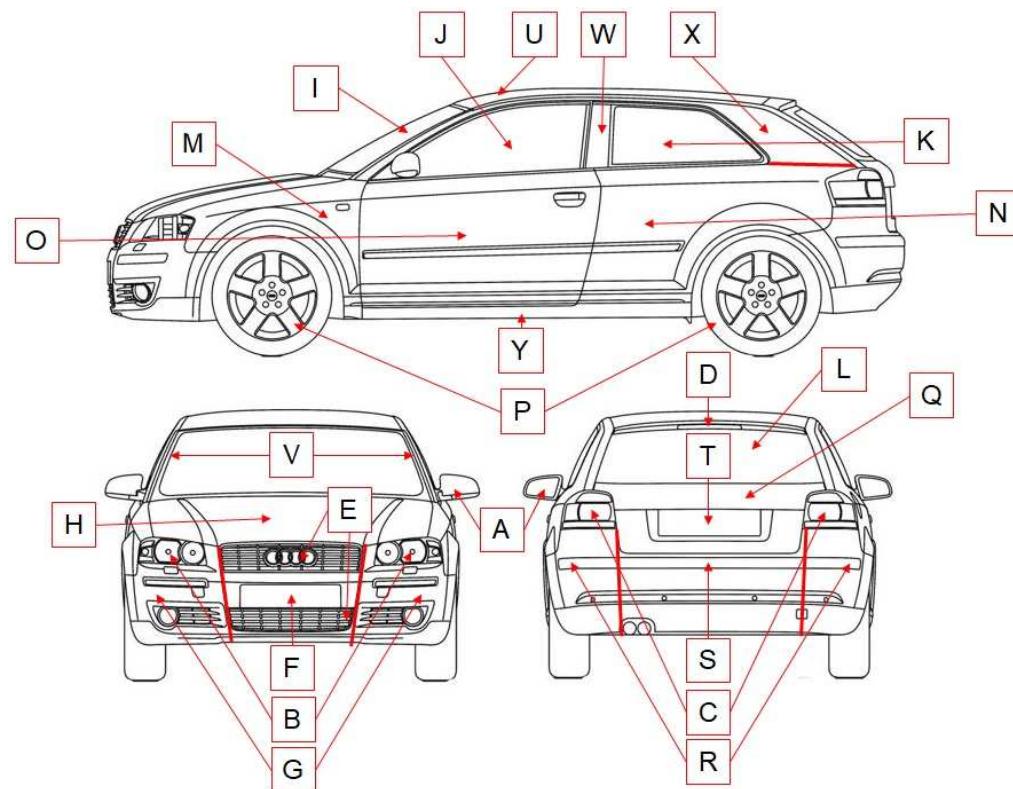
Why we don't show all participants
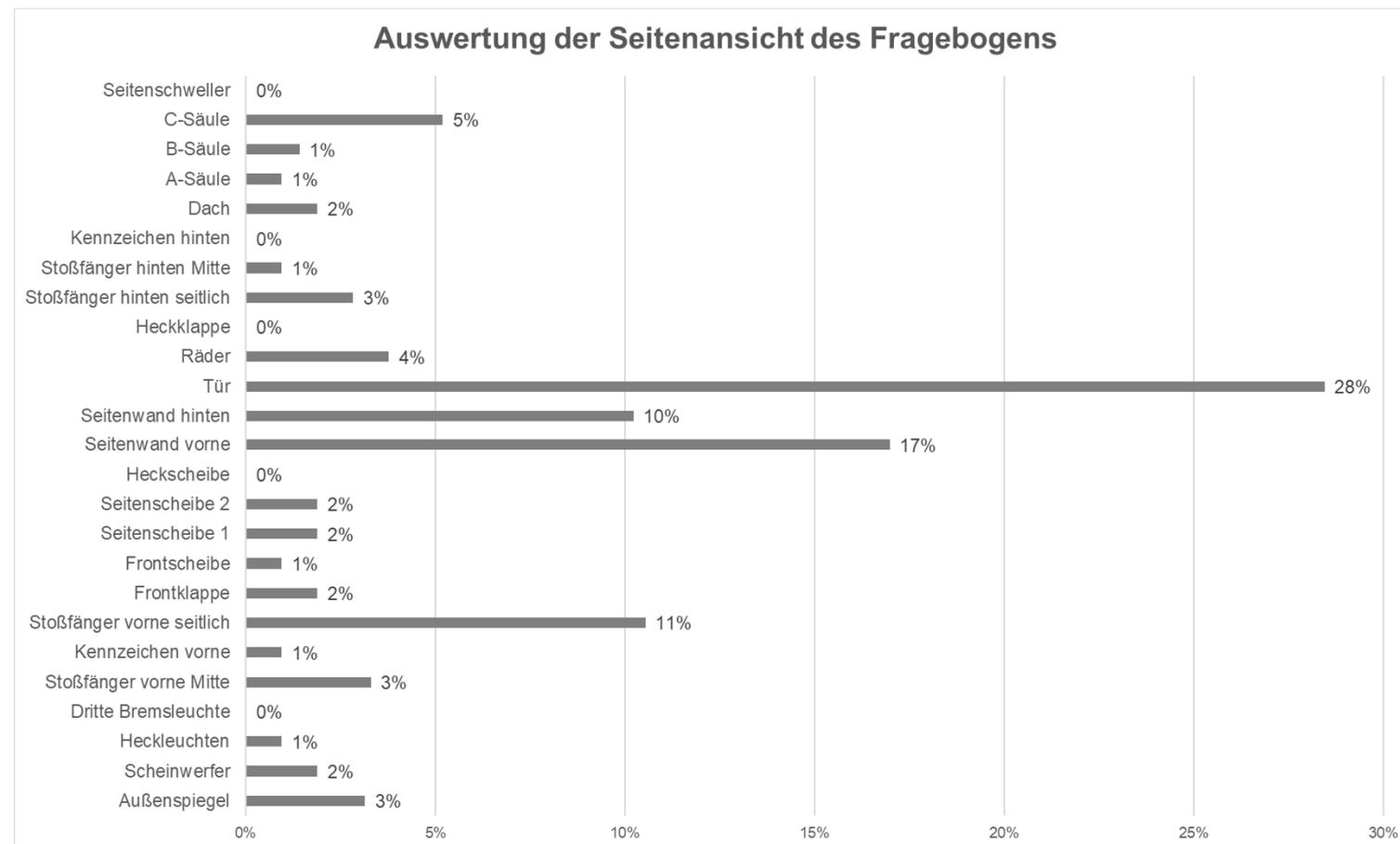
Evaluation: Questionnaire

Question: Where would you expect a label for an autonomous vehicle?
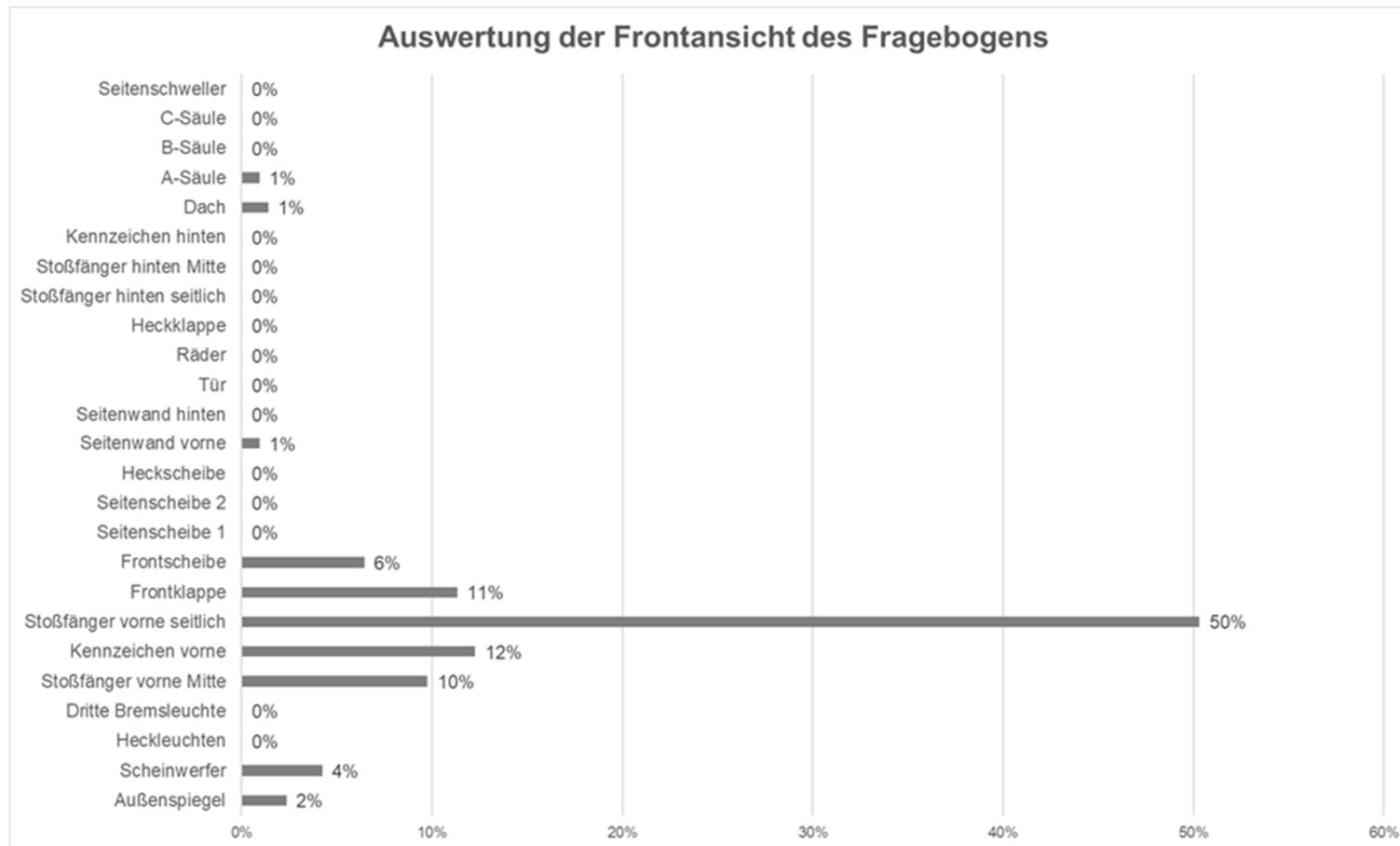
Code	Category (English)	Kategorie (Deutsch)
A	Outside mirror	Außenspiegel
B	Headlights	Scheinwerfer
C	Tail lights	Heckleuchten
D	Third brake light	Dritte Bremsleuchte
E	Front Bumper central	Stoßfänger vorne Mitte
F	Front Licence number	Kennzeichen vorne
G	Front bumper lateral	Stoßfänger vorne seitlich
H	Bonnet	Frontklappe
I	Glass windshield	Frontscheibe
J	Side window 1	Seitenscheibe 1
K	Side window 2	Seitenscheibe 2
L	Rear window	Heckscheibe
M	Front side wall	Seitenwand vorne
N	Rear side wall	Seitenwand hinten
O	Door	Tür
P	Wheels	Räder
Q	Tail gate	Heckklappe
R	Rear bumper lateral	Stoßfänger hinten seitlich
S	Rear bumper central	Stoßfänger hinten mitte
T	Rear Licence number	Kennzeichen hinten
U	Roof	Dach
V	A-pillar	A-Säule
W	B-pillar	B-Säule
X	C-pillar	C-Säule
Y	Side skirt	Seitenschweller
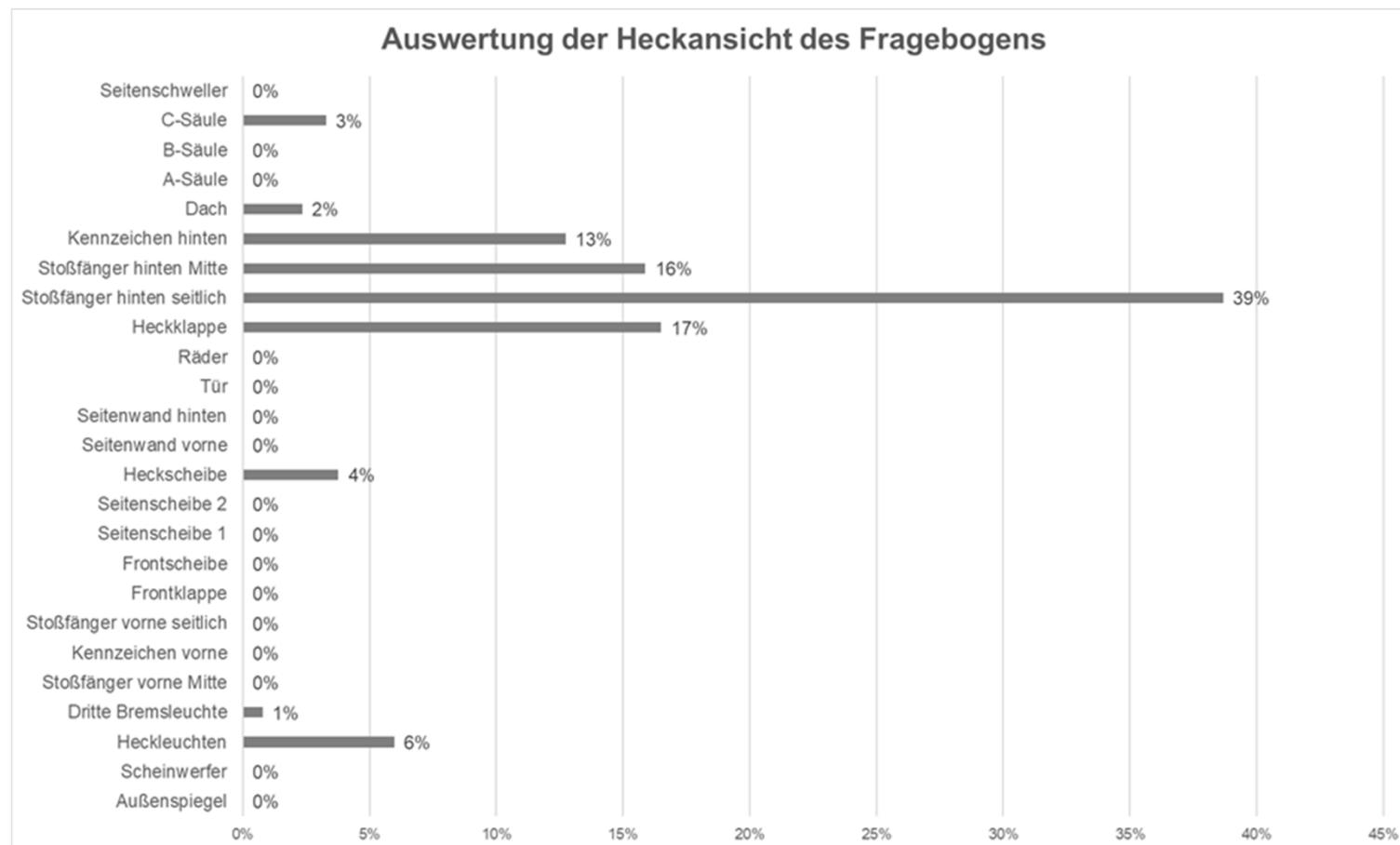
Evaluation of questionnaire: Side view

Evaluation of questionnaire: Front view

Auswertung der Frontansicht des Fragebogens

Seitenschweller	0%
C-Säule	0%
B-Säule	0%
A-Säule	1%
Dach	1%
Kennzeichen hinten	0%
Stoßfänger hinten Mitte	0%
Stoßfänger hinten seitlich	0%
Heckklappe	0%
Räder	0%
Tür	0%
Seitenwand hinten	0%
Seitenwand vorne	1%
Heckscheibe	0%
Seitenscheibe 2	0%
Seitenscheibe 1	0%
Frontscheibe	6%
Frontklappe	11%
Stoßfänger vorne seitlich	50%
Kennzeichen vorne	12%
Stoßfänger vorne Mitte	10%
Dritte Bremsleuchte	0%
Heckleuchten	0%
Scheinwerfer	4%
Außenspiegel	2%

Evaluation of questionnaire: Rear view

Auswertung der Heckansicht des Fragebogens

Kategorie	Wert
Seitenschweller	0%
C-Säule	3%
B-Säule	0%
A-Säule	0%
Dach	2%
Kennzeichen hinten	13%
Stoßfänger hinten Mitte	16%
Stoßfänger hinten seitlich	39%
Heckklappe	17%
Räder	0%
Tür	0%
Seitenwand hinten	0%
Seitenwand vorne	0%
Heckscheibe	4%
Seitenscheibe 2	0%
Seitenscheibe 1	0%
Frontscheibe	0%
Frontklappe	0%
Stoßfänger vorne seitlich	0%
Kennzeichen vorne	0%
Stoßfänger vorne Mitte	0%
Dritte Bremsleuchte	1%
Heckleuchten	6%
Scheinwerfer	0%
Außenspiegel	0%

Procedure for evaluation of eye movements

- Focus map: Shows the important areas for the participants

- AOIs: Created from the focus map for better visualization

Focus Map

AOIs

How does the Focus Map work?

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How does the Focus Map work?

Evaluation of eye movements: Procedure

- **Key figures of the Areas of Interest (AOIs) were evaluated:**
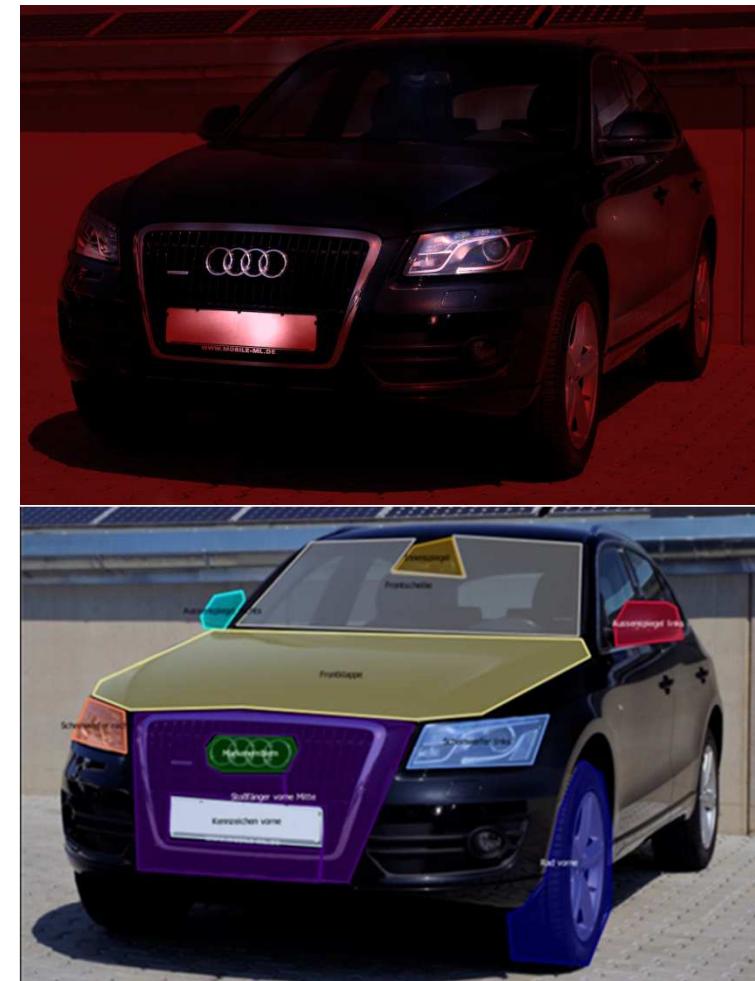
→**Hit ratio:** <u>Percentage</u> of participants which focus on respective AOI
(How many participants do even notice the AOIs)

→**Entry time:** <u>Average</u> time to focus on the respective AOI
(How much time need the participants to focus the AOIs)

→**Dwell time:** <u>Average</u> focus-time on respective AOI
(How long do the participants stay on the AOIs)

Categorization of the angled front view

- Examined AOI:
  - →inside mirror
  - →windshield
  - →outside mirror left and right
  - →bonnet
  - →headlight left and right
  - →front bumper central
  - →badge
  - →front wheel
  - →front license plate
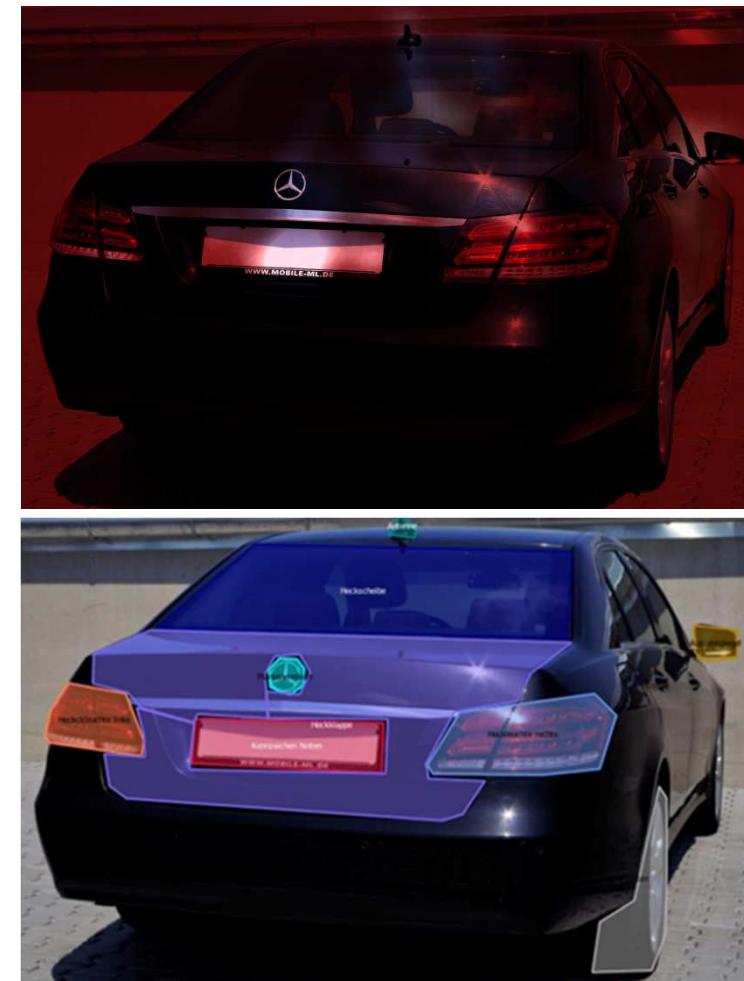
Categorization of the side view

- Examined AOI:
  - →headlight
  - →front side wall
  - →outside mirror
  - →door 1 and door 2
 - →side window 1 and side window 2
  - →front wheel
  - →rear wheel
  - →tail light

Categorization of the angled rear view

- Examined AOI:
  - →antenna
  - →rear window
  - →tailgate
  - →badge
  - →rear license plate
  - →tail light left and right
  - →rear wheel
  - →right outside mirror

Evaluation of Control Test AND Fake test

- Evaluation for <u>all picture types</u> separated into: Front, side and rear view
- Formula to calculate the reached points for every AOI (bumper, headlights,....) of the different views



```
-   Highest Hit Ratio and Dwell Time = highest points
-   Lowest Entry Time = highest points
```
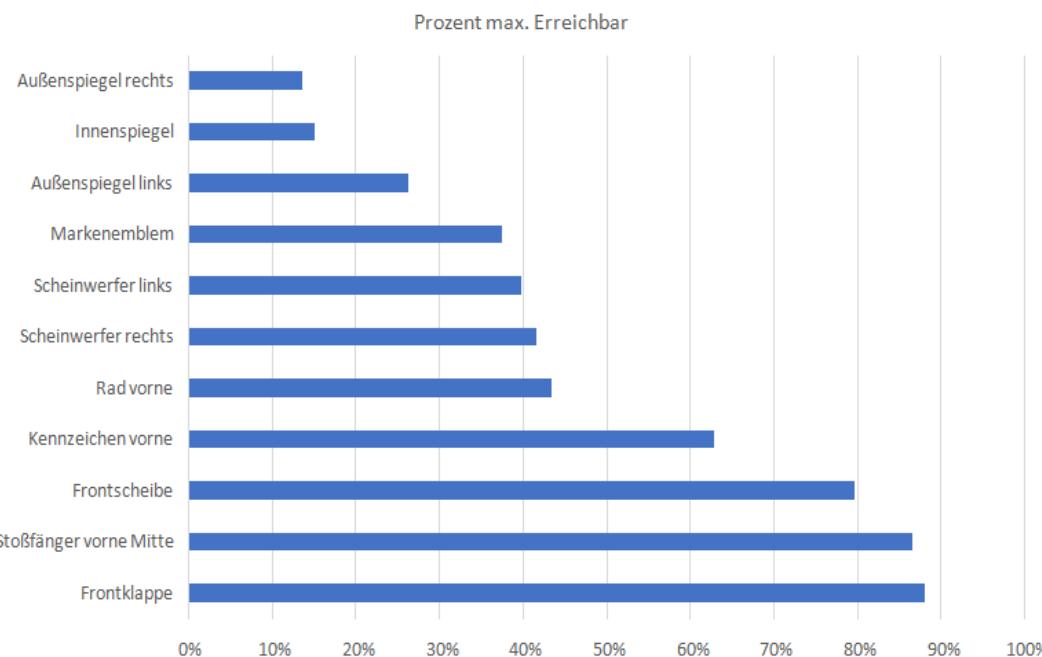
```
-   Hit Ratio = 3
-   Entry Time = 1
-   Dwell Time = 3
```

$$\% = \frac{\Sigma\ points \cdot coefficient}{max.achievable\ points \cdot coefficient}$$

- The results of the control test and fake test are almost the same
  → Only the dwell time is affected of the falsely told information
  → For a better overview all results are put together in the following diagrams
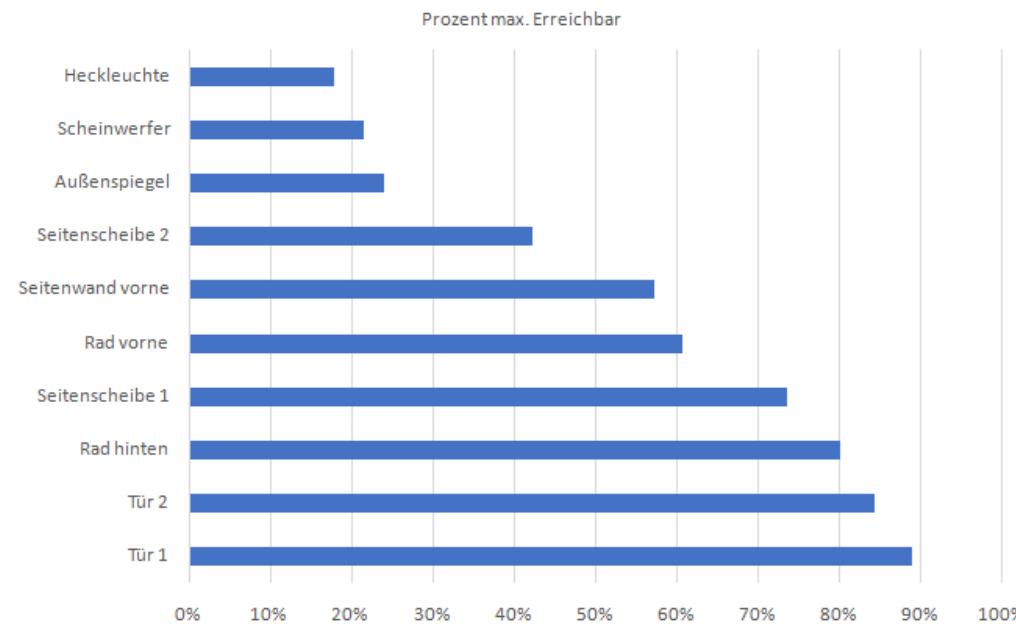
Evaluation of Control Test AND Fake test: Front view

- Best results:
  - →Bonnet
 - →Front Bumper central
  - →Glass windshield

Prozent max. Erreichbar

Außenspiegel rechts
Innenspiegel
Außenspiegel links
Markenemblem
Scheinwerfer links
Scheinwerfer rechts
Rad vorne
Kennzeichen vorne
Frontscheibe
Stoßfänger vorne Mitte
Frontklappe

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

GI · CH 6568

more interessting

less interessting
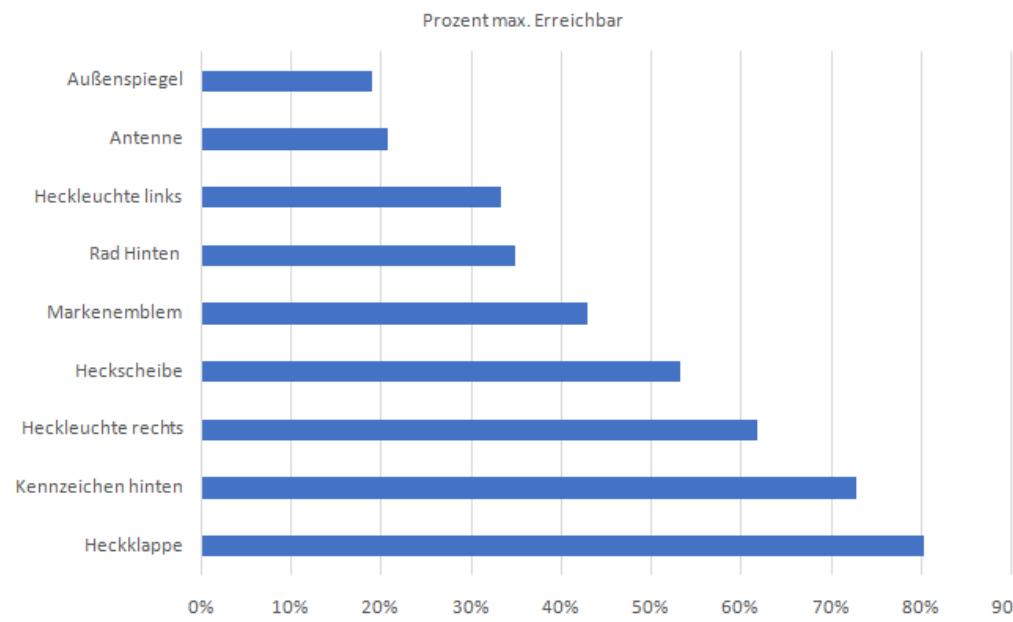
Evaluation of Control Test AND Fake test: Side view

- Best results:
  →Door 1
  →Door 2
  →Rear Wheel

Evaluation of Control Test AND Fake test: Rear view

- Best results:
  - →Tail gate
  - →Rear licence number
  - →Tail light (right)

Prozent max. Erreichbar

Außenspiegel	
Antenne	
Heckleuchte links	
Rad Hinten	
Markenemblem	
Heckscheibe	
Heckleuchte rechts	
Kennzeichen hinten	
Heckklappe	

0%   10%   20%   30%   40%   50%   60%   70%   80%   90%

Conclusions - Summary of the study 1/2

- The eye movement data acquired during the trial was evaluated in terms of hit ratio, entry time and dwell time to determine areas of interest (AoIs)

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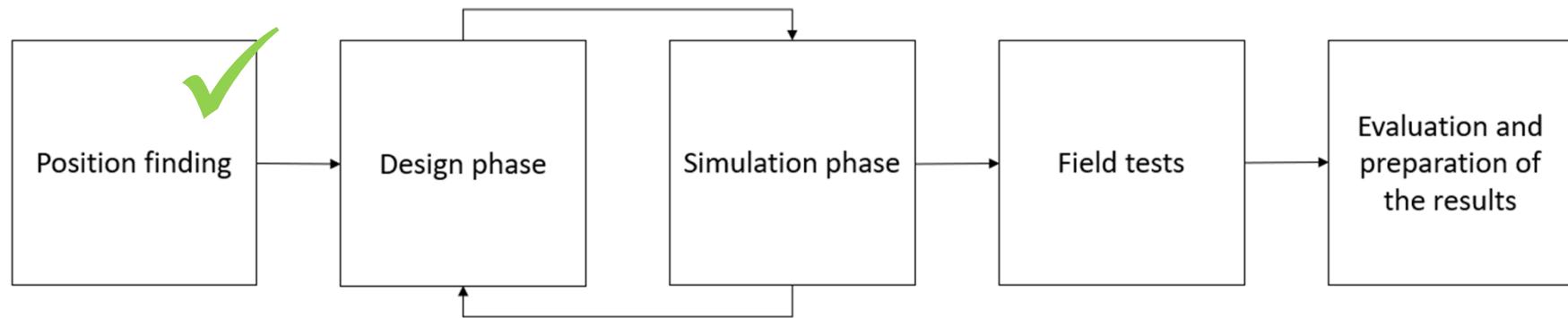
Conclusions - Summary of the study 2/2
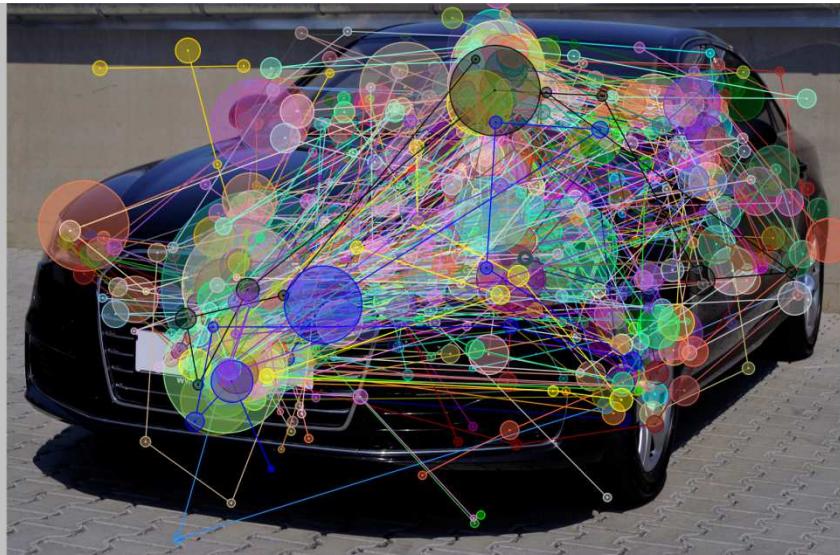
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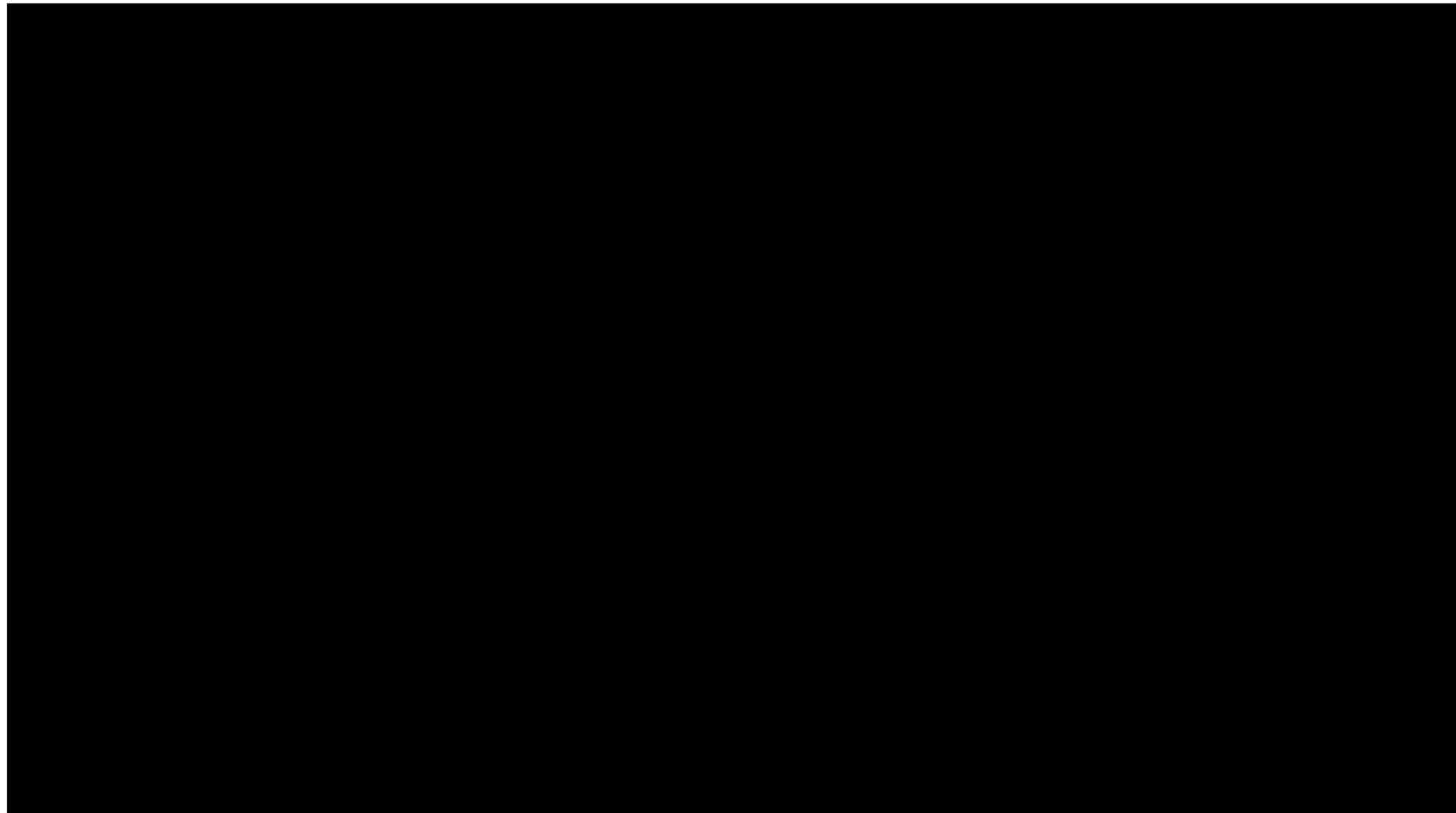
Favourable positions for a labelling

| View	position / category	comment
side view	front door	very good key figures; partially high entry time; winner questionnaire
	side window	very good key figures; partially high entry time
	front fender	good key figures; low entry time
	lateral front bumper	if needed; good key figures in picture category 3
front view	lateral front bumper	if needed; winner questionnaire
	windshield	very good key figures; partially high entry time
	bonnet	very good key figures; partially high entry time
	center front bumper	verification needed; good key figures
	headlights	if needed; low entry time
rear view	tailgate	very good key figures
	tail lights	good key figures; low entry time
	lateral rear bumper	if needed; winner questionnaire
	rear window	if needed; good key figures

What's next?

Thank you for your attention!
Any questions?

https://www.osk.de/blog/wp-content/uploads/2015/06/14C1450_116-e1433254267453.jpg (19.09.2018)