Estimating Visual Demands in Road Traffic Environments

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Overview

Objective To investigate occlusion methods that are sensitive to changes in visual demand according to different road traffic environments

Occlusion method

Controlling the permitted time intervals during which a driver can/cannot look at a scene, by the driver's request

Findings

- The occlusion method estimating the locations where the driver can safely interact with the in-vehicle systems
- Perceived minimum visual demand and sufficient visual demand

History of occlusion methods

1967
The first demonstration on a real road by Dr. John W. Senders


Occlusion : Open


Occlusion : Close

2000s Several experiments using driving simulators
- Assessing visual demands of several curves with different curve radii and different deflection angles
- Investigating perceived visual demands between the driver's age

2001 Workshop@UMTRI: Exploring the Occlusion Technique

2004 Journal: *Applied Ergonomics*
Special issues; The occlusion technique: a procedure to assess the HMI of in-vehicle information and communication systems

2004 JAMA Guidelines for In-vehicle Display Systems Ver. 3.0
TSOT (total of shutter opening time) in the occlusion method

2007 ISO 16673: Occlusion method to assess visual demand due to the use of in-vehicle systems

Objective

To investigate methods of occlusion that are sensitive to changes in visual demand according to different road traffic environments

What is “Sensitivity”

– Assume that the different road traffic environments have different objective visual demands
– “Sensitivity” corresponds to their ability to reflect these differences

Implications of this study

Accurate estimation of visual demands contributes to identifying driving situations where drivers have sufficient capacity to divide their attention to the in-vehicle systems.

Experimental flow

Comparison of 4 occlusion methods to estimate visual demands during driving with and without lead vehicles

Environments: Rural road
Traffic conditions: Car-following and solo-driving
Participants: 8 drivers (4 females, Average age: 36.3 years old (27-42))

Comparison of the selected occlusion methods to estimate visual demands of road structures: straight roads, curved roads, merging at junctions, diverging at junctions, and an entrance and an exit of a tunnel

Environments: Tokyo Metropolitan Expressway
Traffic condition: Solo-driving
Participants: 21 drivers (11 females, Average age: 38.3 years old (22-58))

4 kinds of occlusion methods in this study

Road scene is normally occluded.

(1) Driver's depression of a switch allows the road scene to be viewed **for 0.6 seconds**

(3) The driver is allowed to view the road **while depressing a switch**

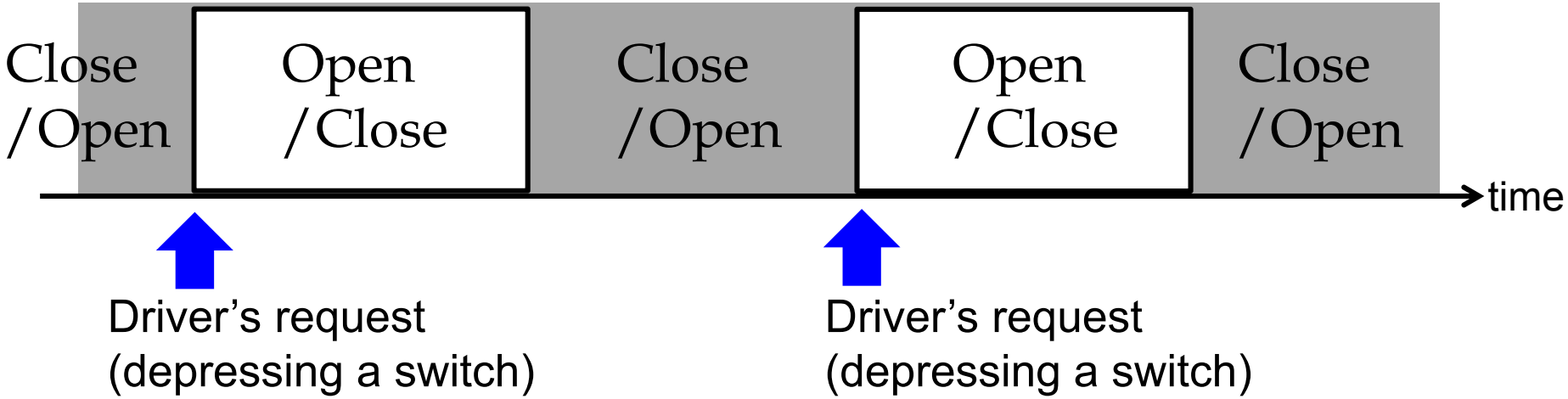
Road scene is normally visible.

(2) Driver's depression of a switch blanks out the driver's vision **for 1.5 seconds**

(4) The driver's vision is blanked out **while depressing a switch**

Quantification of visual demands in occlusion methods

[Definition] Visual demand as the proportion of time when the road was visible during a specific driving interval

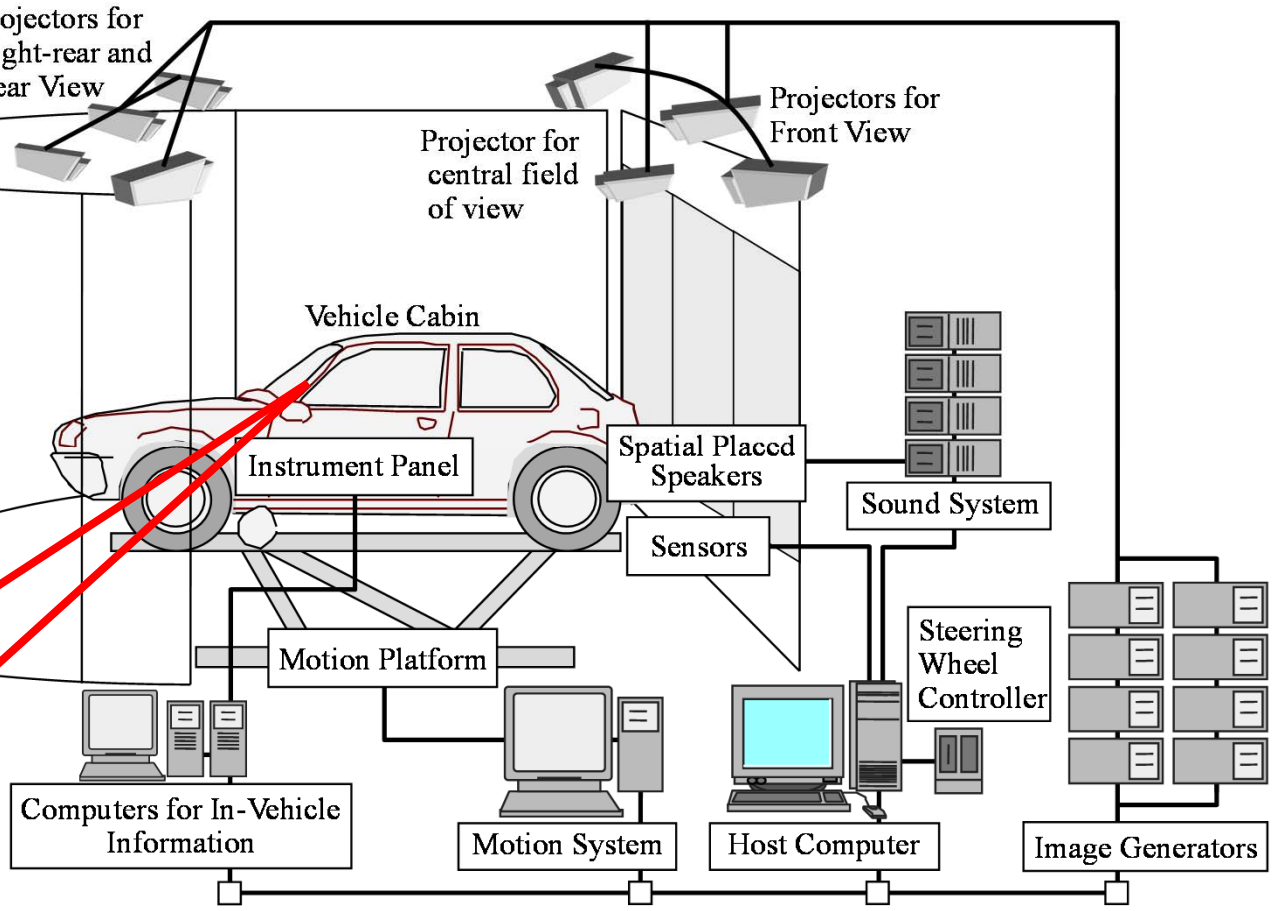


$$\text{Viewing rate} = \sum \frac{\text{Viewing time of the road scene at the previous request}}{\text{Time between previous request and current request}}$$

$$= \frac{\text{Sum of the viewing time}}{\text{Driving time}}$$

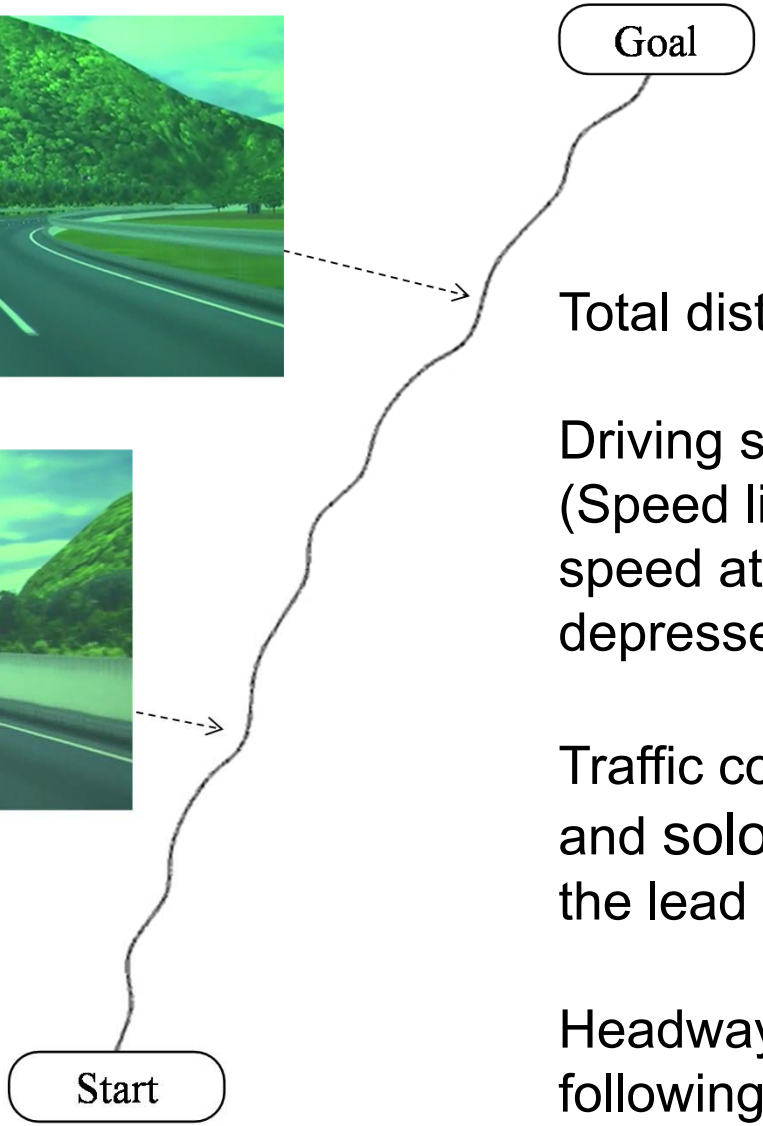
AIST driving simulator

High resolution of center area in the front scene



The switch for the driver's request

Driving conditions



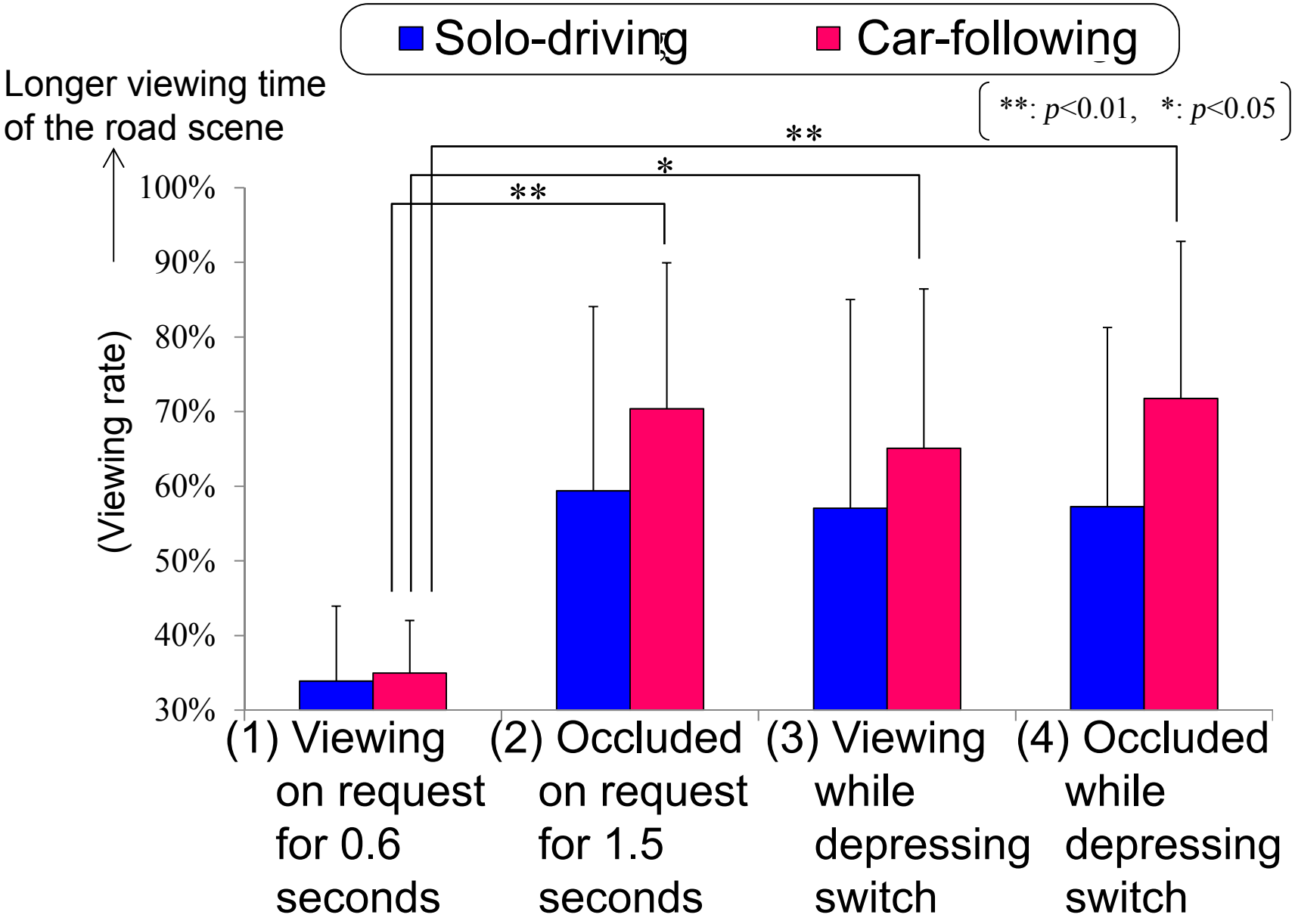
Total distance of the route: 5.4km

Driving speed: about 60km/h (Speed limiter held the maximum speed at 63 km/h while the driver depressed the accelerator pedal.)

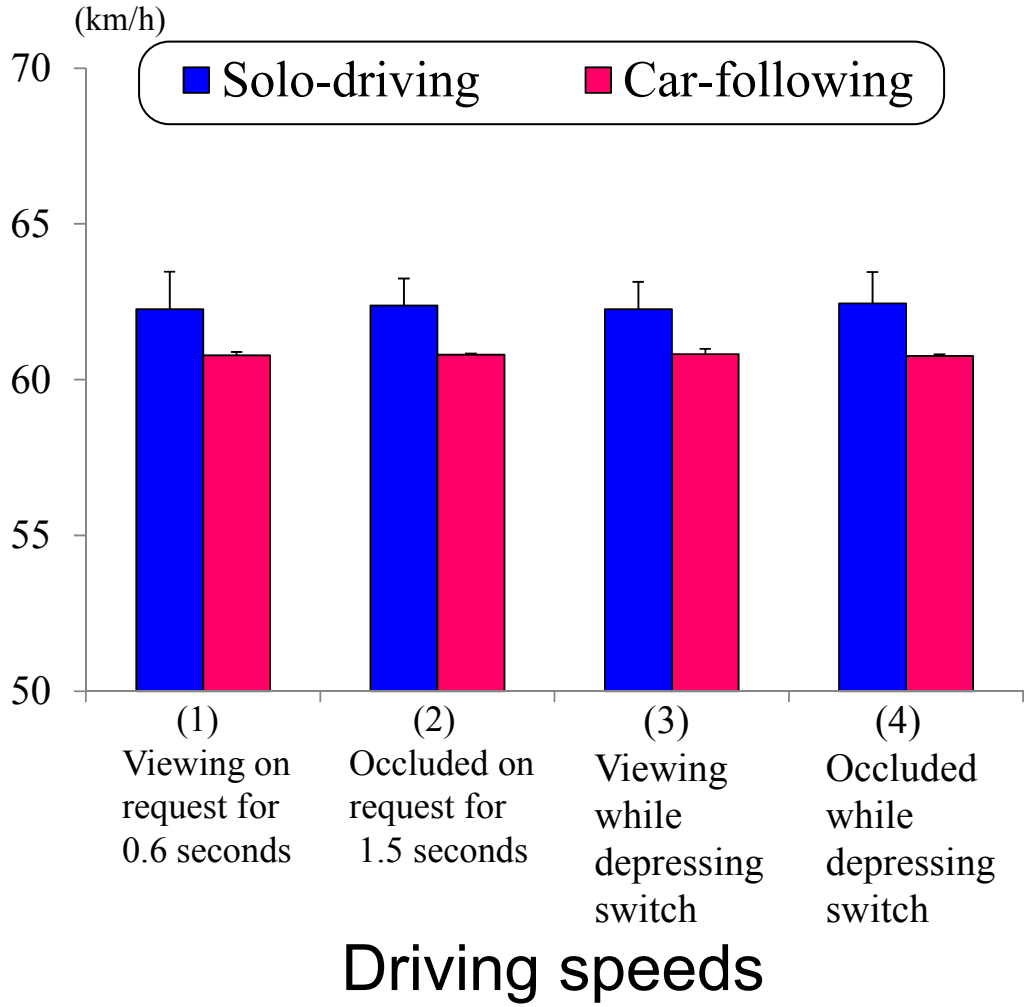
Traffic conditions: Car-following and solo-driving (driving without the lead vehicles)

Headway distance in the car-following condition: around 25m

Result: viewing rates

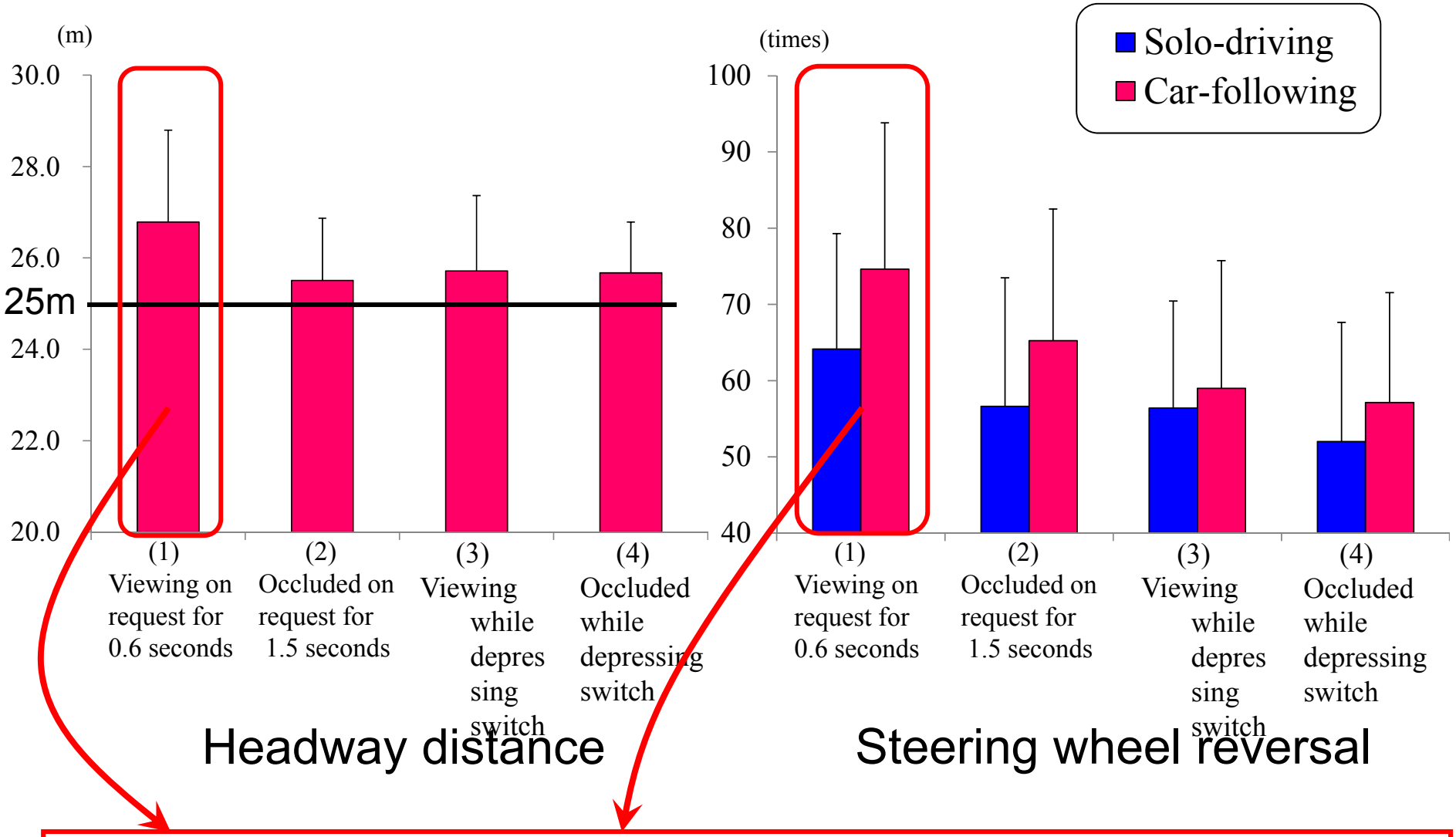


Result: driving behaviors(1/2)



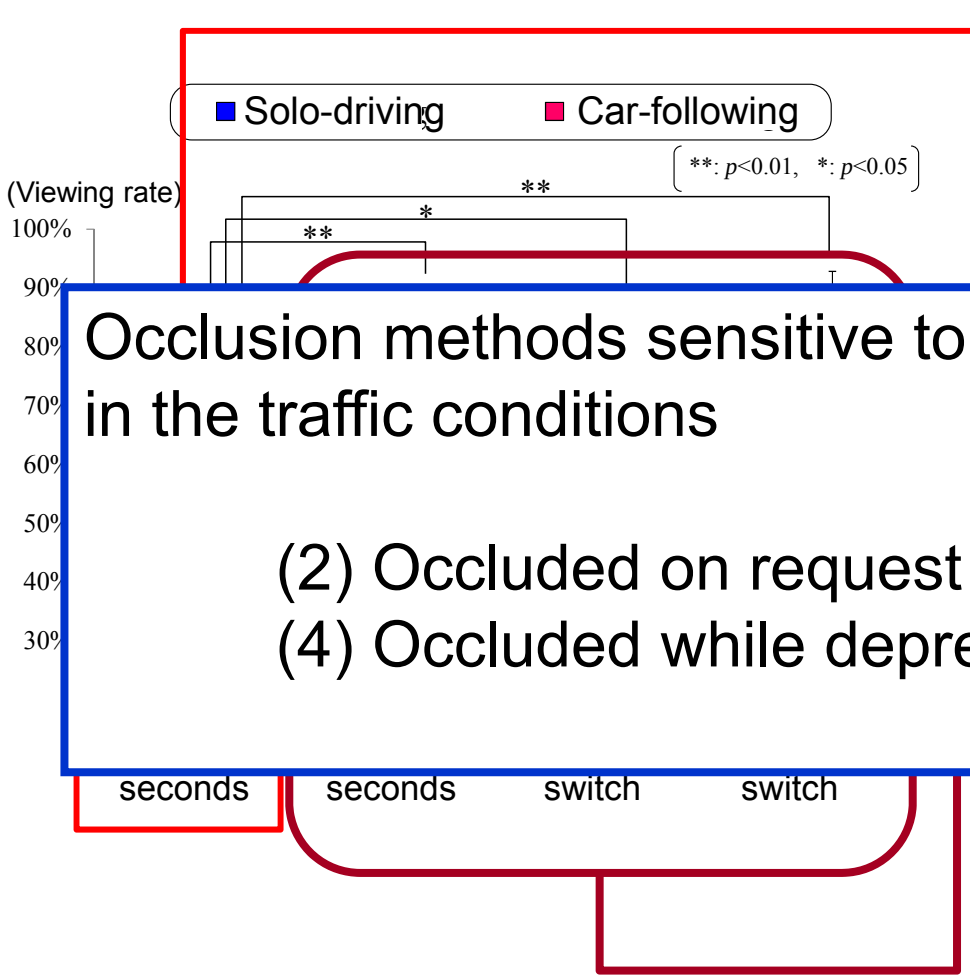
No differences between the occlusion methods in each traffic condition

Result: driving behaviors (2/2)



Longer headway distance and larger steering wheel reversals with occlusion method (1) than with the other occlusion methods

Discussion



The drivers received only the minimum information required for maintaining the driving speed.

➔The same viewing rates

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Occlusion methods sensitive to visual demand variations in the traffic conditions

(2) Occluded on request for 1.5 seconds

(4) Occluded while depressing switch

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➔Especially, when drivers controlled their attention allocation to a secondary task, the driver processed more information to better understand the movements of the lead vehicles

Experimental flow

Comparison of 4 occlusion methods to estimate visual demands during driving with and without lead vehicles

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Environments: Tokyo Metropolitan Expressway
Traffic condition: Solo-driving
Participants: 21 drivers (11 females, Average age: 38.3 years old (22-58))

Driving route

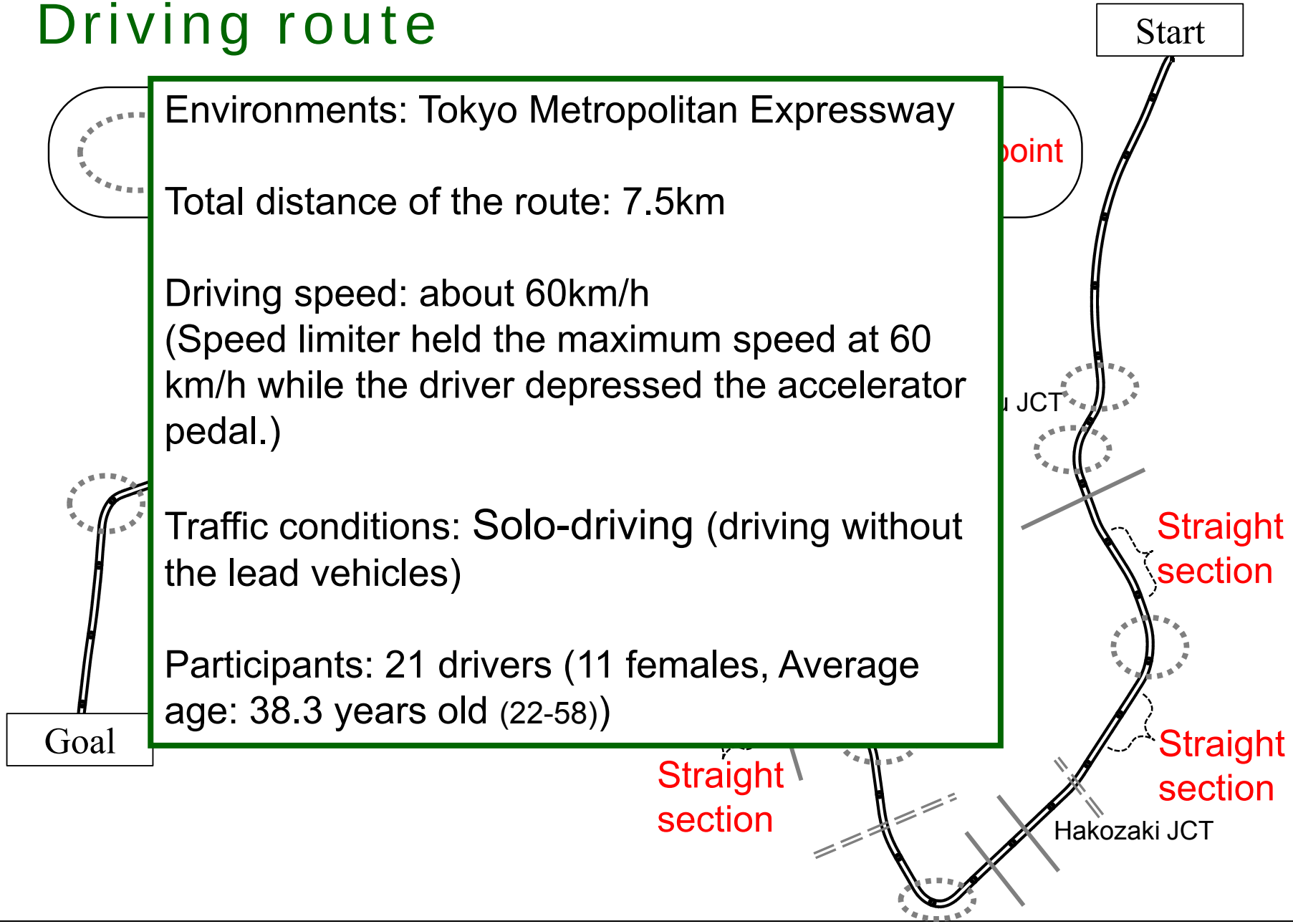
Environments: Tokyo Metropolitan Expressway

Total distance of the route: 7.5km

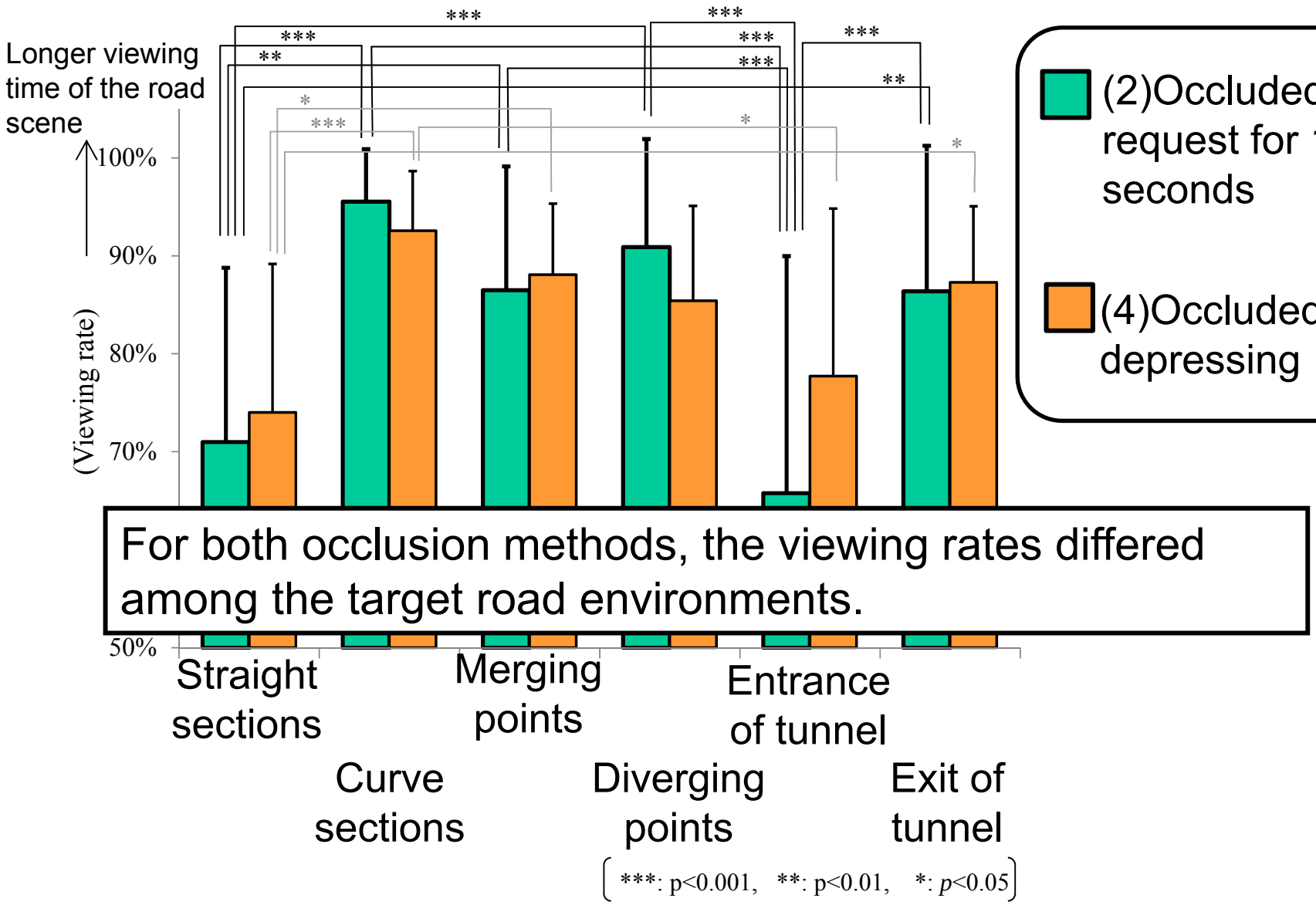
Driving speed: about 60km/h
(Speed limiter held the maximum speed at 60 km/h while the driver depressed the accelerator pedal.)

Traffic conditions: Solo-driving (driving without the lead vehicles)

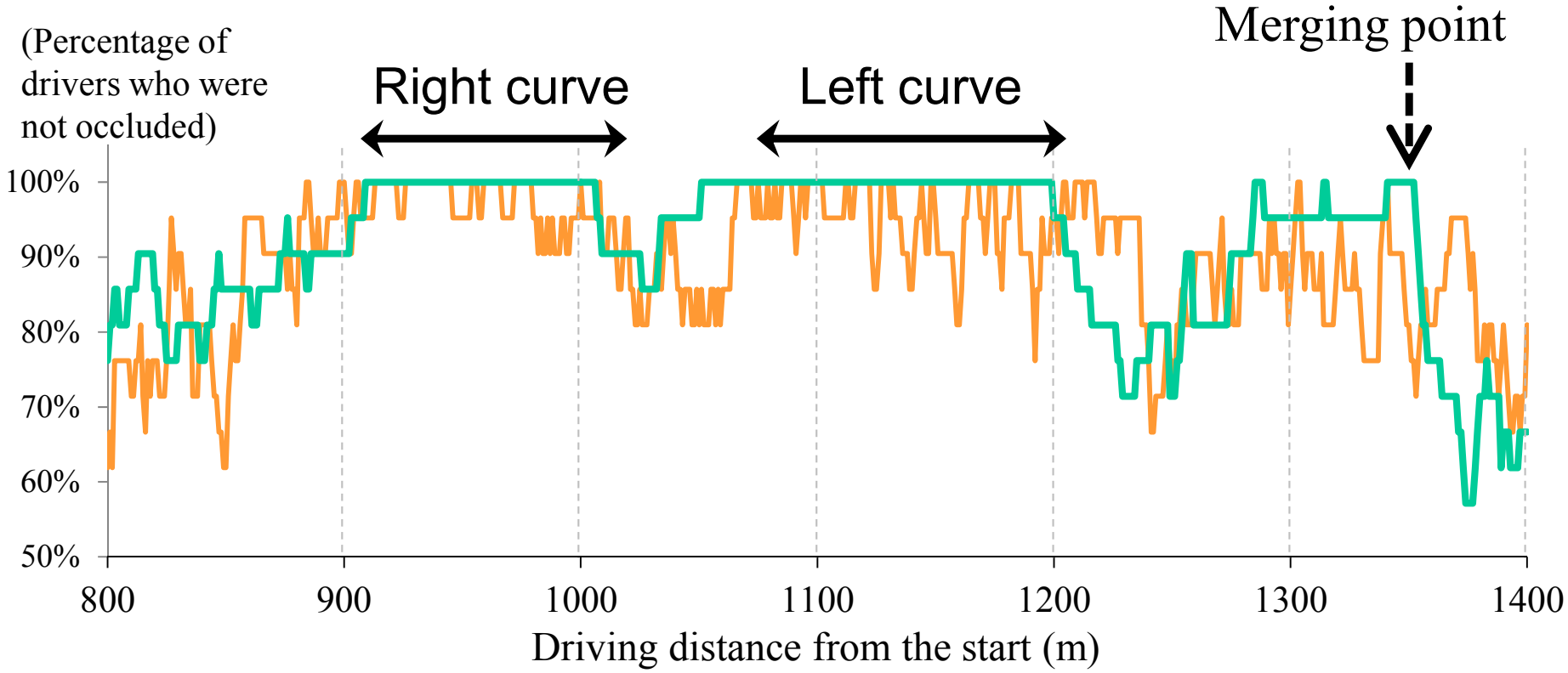
Participants: 21 drivers (11 females, Average age: 38.3 years old (22-58))



Result: viewing rates (1/2)



Result: viewing rates (2/2)



- None of the participants depressed the switch while driving on left and right curves or just before the merging point.
- Some participants depressed the switch during the curved sections or before the merging point.

Discussion

- Both occlusion methods (2) and (4) were sensitive to the visual demands derived from the road environments.

- All participants using occlusion method (2) did not depress the switch while driving on curves or just before the merging points.

➔Useful in finding locations where a driver could perform in-vehicle tasks

- Some drivers using occlusion method (4) were occluded at their request even during the curves or before the merging points.

➔Influenced by driver personality: driver's confidence in managing the driving task successfully under a brief occluded condition

Conclusions

- We investigated occlusion methods to estimate quantitatively the perceived visual demand in road traffic environments.

- The occlusion methods, the road scene was normally visible and was occluded by the driver's request, were sensitive to the visual demands derived from the road traffic environments.
  - ➢ The pattern with a pre-determined occlusion time ➔identifying the locations where a driver can pay attention to an in-vehicle task
  - ➢ The pattern with a self-paced occlusion time ➔influenced by the driver's personal characteristics

- The minimum visual demand when performing only the maintenance of velocity was estimated by the occlusion method: the road scene was normally closed and opened for a specific time at the driver's request.

- The sufficient visual demand to achieve a higher performance level was measured by the occlusion methods: the road scene was normally visible and was occluded by the driver's request

Thank you for your attention!

Task-capability interface model

Drivers adjust the task difficulty while driving, and the task difficulty can be determined as an interaction between the driver capability and the task demands.