Human Factors

For safe and socially acceptable technology

Theme1:

- The project term is 3 years with Year 1 (FY2016) funded by the Cabinet Office and Year 2 and 3 (FY2017 and 2018) funded by NEDO (New Energy and Industrial Technology Development Organization).
- The project is being conducted by a consortium consisting of AIST (National Institute of Advanced Industrial Science and Technology), DENSO Co., Tokyoto Business service Co., University of Tsukuba and Keio University.
- Potential human factor problems were extracted using the framework with three human-system interactions between the system and the driver, system and surrounding road users, and between the system and the society (Figure 1).
- Based on the overview of the problems, three tasks A, B and C were set as those with the highest priority.

Task A investigates effects of system information (static and dynamic) on drivers' behavior in transition from Levels 2 and 3 to manual.

Task B investigates effects of driver state (readiness) on his/her behavior in transition from Levels 2 and 3 to manual.

Task C studies non-verbal communication between drivers and other road users, and investigates effective ways to functionalize the automated vehicle to be communicative.

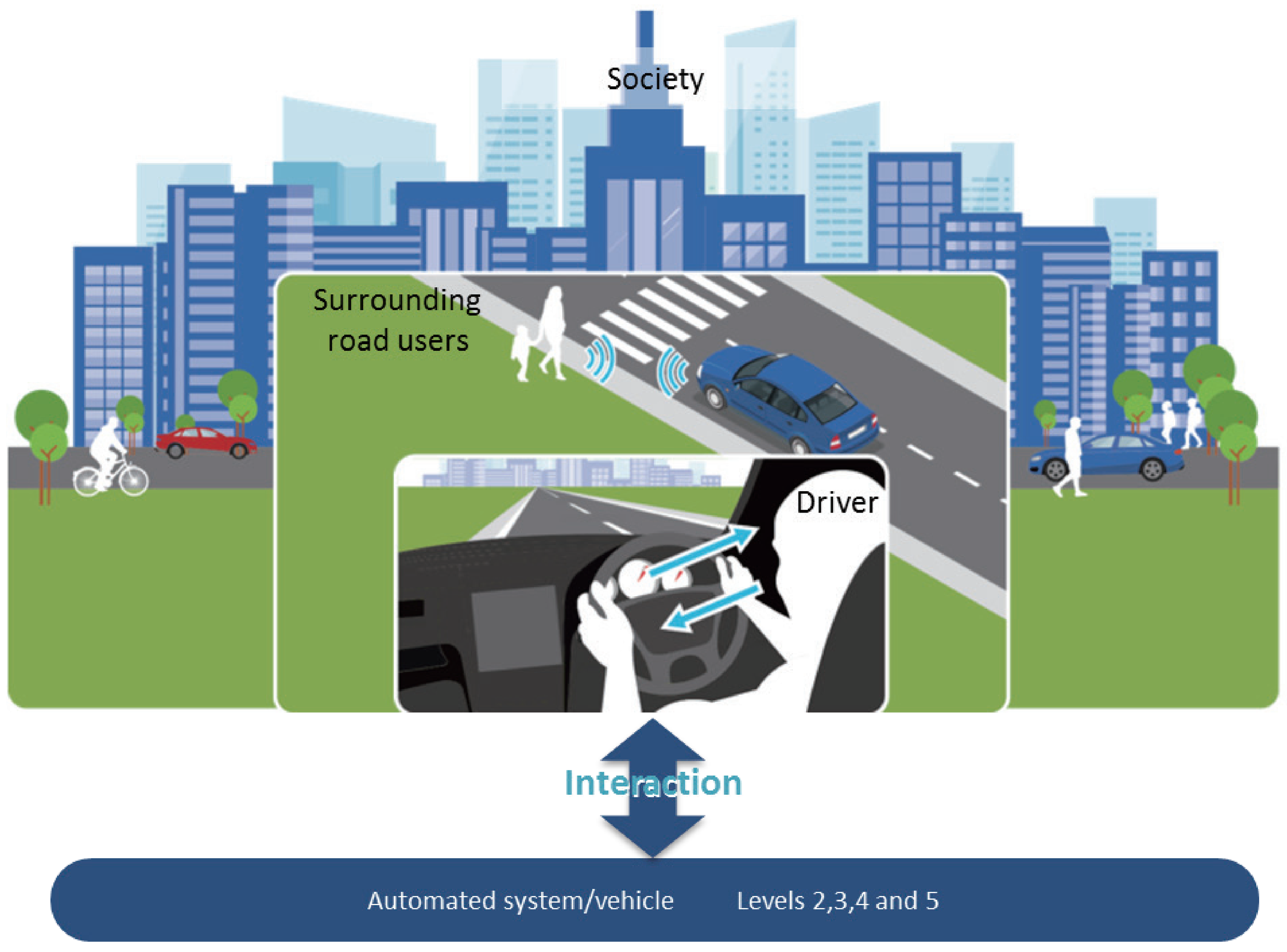

Figure 1 The framework used to extract potential human factor problems.

Task A

1. Aim (Year 1)

To investigate effects of static information of the system (knowledge) on drivers' behavior in transition from Level 3 to manual.

2. Method

A total of 10 younger subjects (up to 55 y.o.) and 10 older subjects (65 y.o. and older) participated in the experiment. The subjects were given various controlled information about functions and limitations of the Level 3 system before driving the system in the driving simulator. They placed their hands off the steering wheel and performed the additional visual-manual task (SuRT※) while driving with the automated system on the motorway. The TOR signal went off for the subject to take-over the driving task to exit the motorway at the following junction. Subjects' behavior in transition was analyzed as a function of the given information.

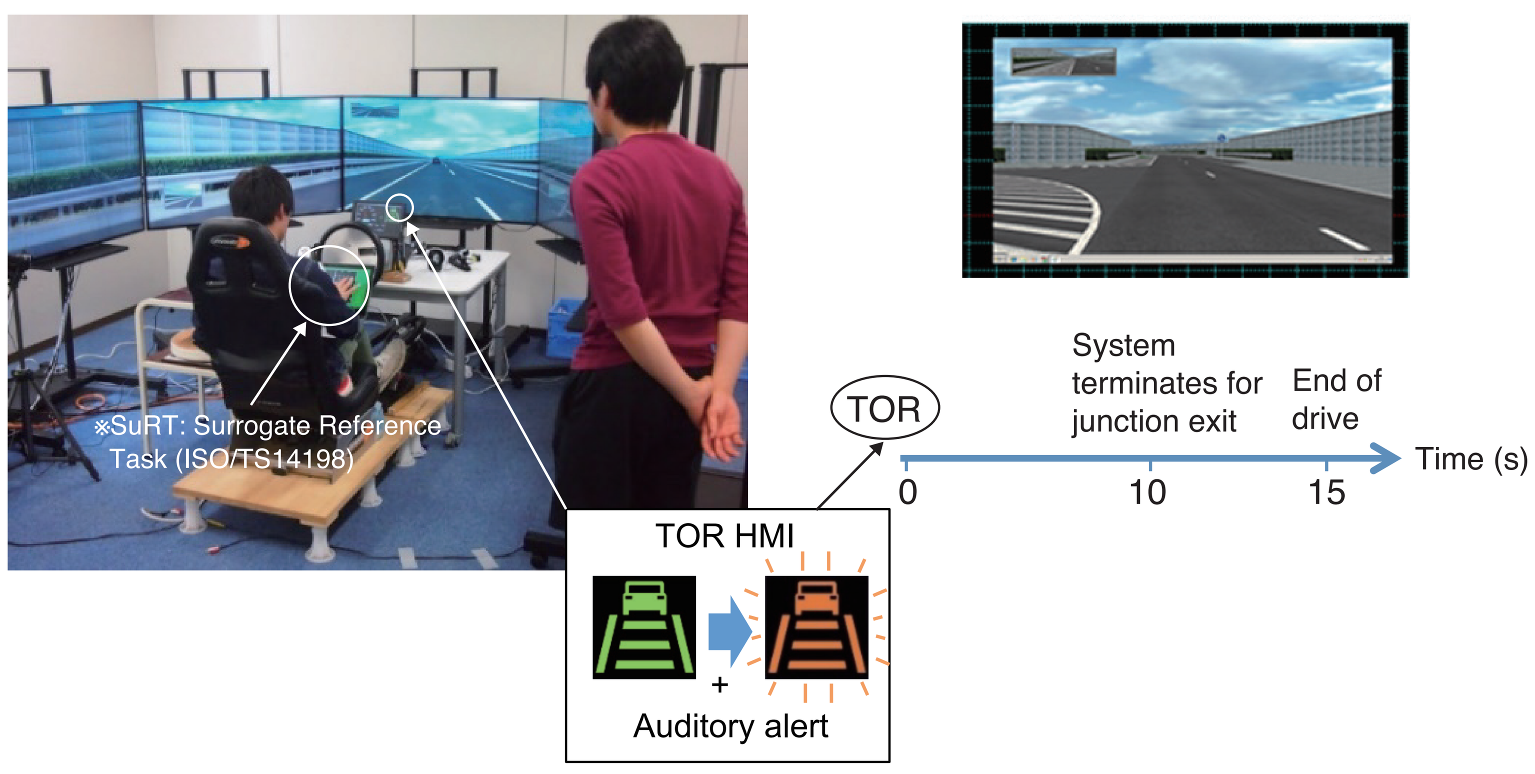

Figure 2 Experimental set-up in the driving simulator and the scenario used.

3. Results

- Information about take-over situations was found to be important for successful take-over (Cond. 1-3 vs Cond. 4,5 in Figure 3).
- However, too much information about take-over situations degraded subjects' behavior especially for older subjects (Cond. 5 in Figure 3).
- Experiencing take-over situations improved the success rate in some conditions although the effect was smaller for the older subjects (Figure 4).

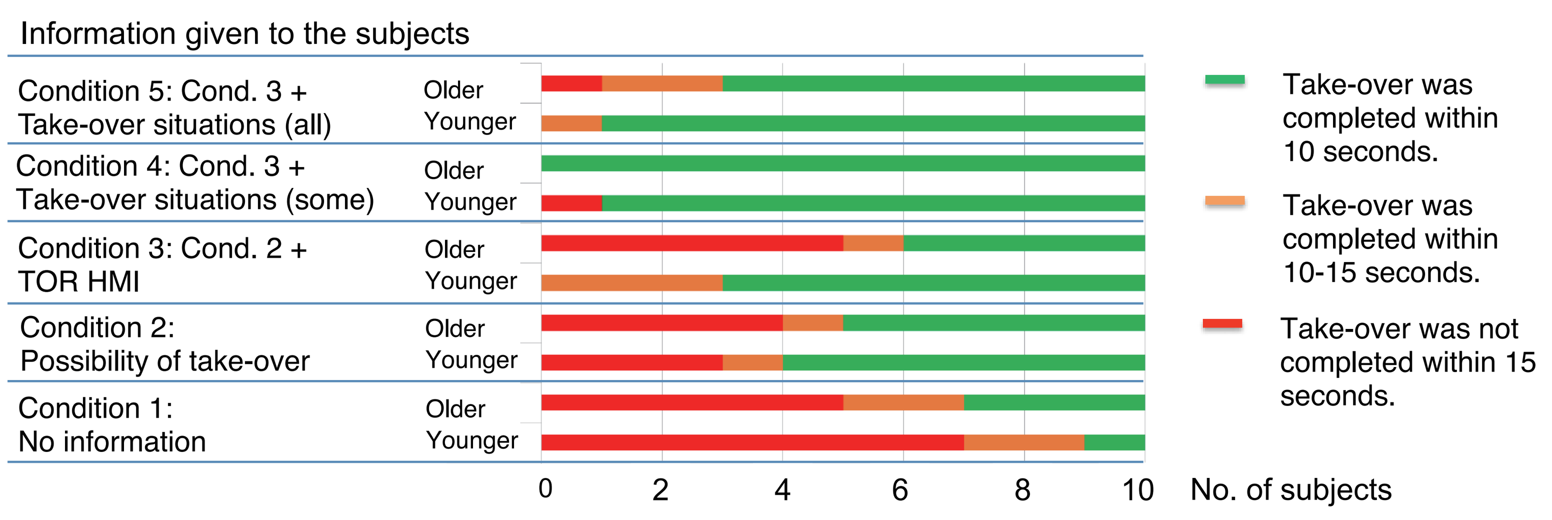

Figure 3 Take-over performance for different pre-driving information.

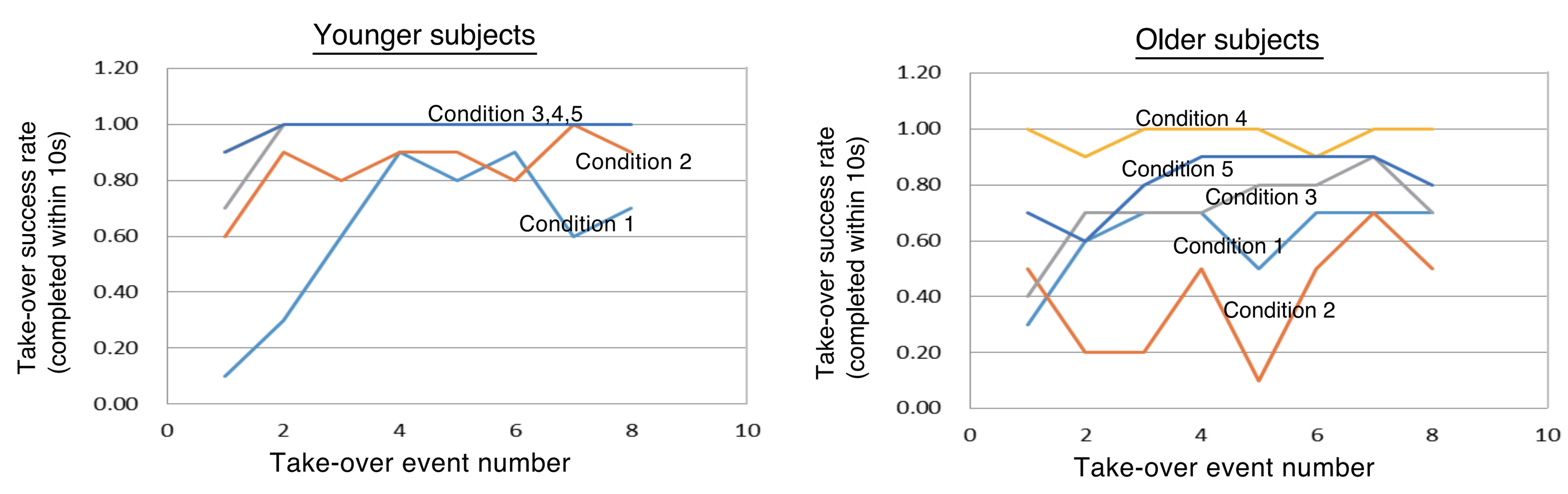

Figure 4 Changes in the take-over success rate as a function of the number of experienced event.

4. Conclusion

Combination of good contents of pre-driving information and experiencing similar situations are effective for successful take-over.

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Task B

1. Aim (Year 1)

To investigate effects of driver state (readiness) with Level 2 and 3 systems on his/her behavior in transition to manual and extract metrics of readiness for the driver monitoring system.

2. Method

A total of 81 subjects drove Level 2 and 3 systems with cognitive and physical additional tasks in the driving simulator while subjects' physiological metrics were measured. The scenario included several events with low criticality where the subjects took over the driving task after TOR. Subjects' physiological metrics correlated with the driver state and degraded performance in the events were extracted.

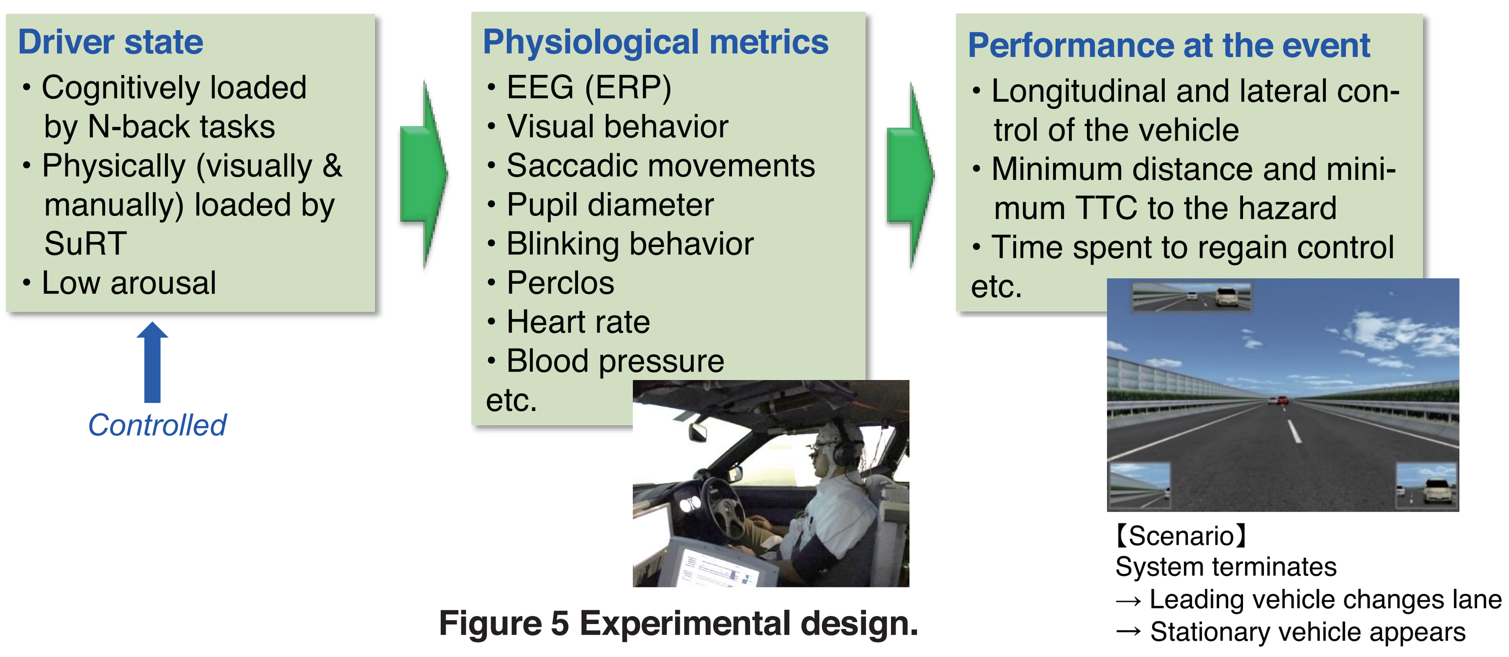

Figure 5 Experimental design.

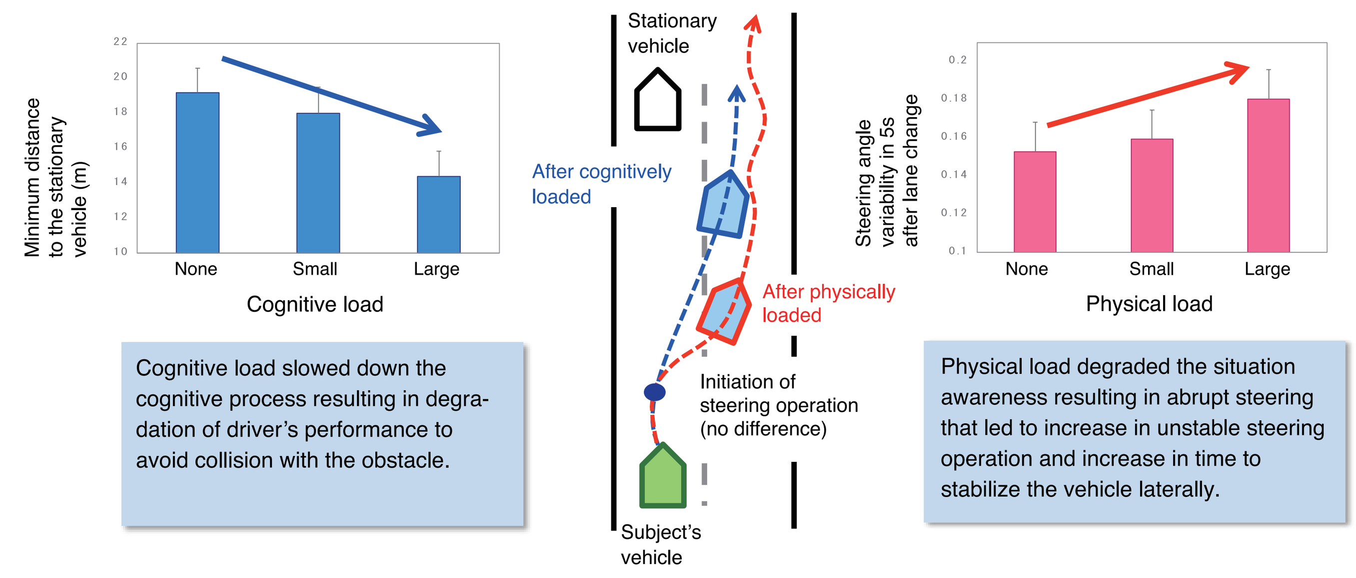

Figure 6 Effects of driver state on driver's behavior in transition.

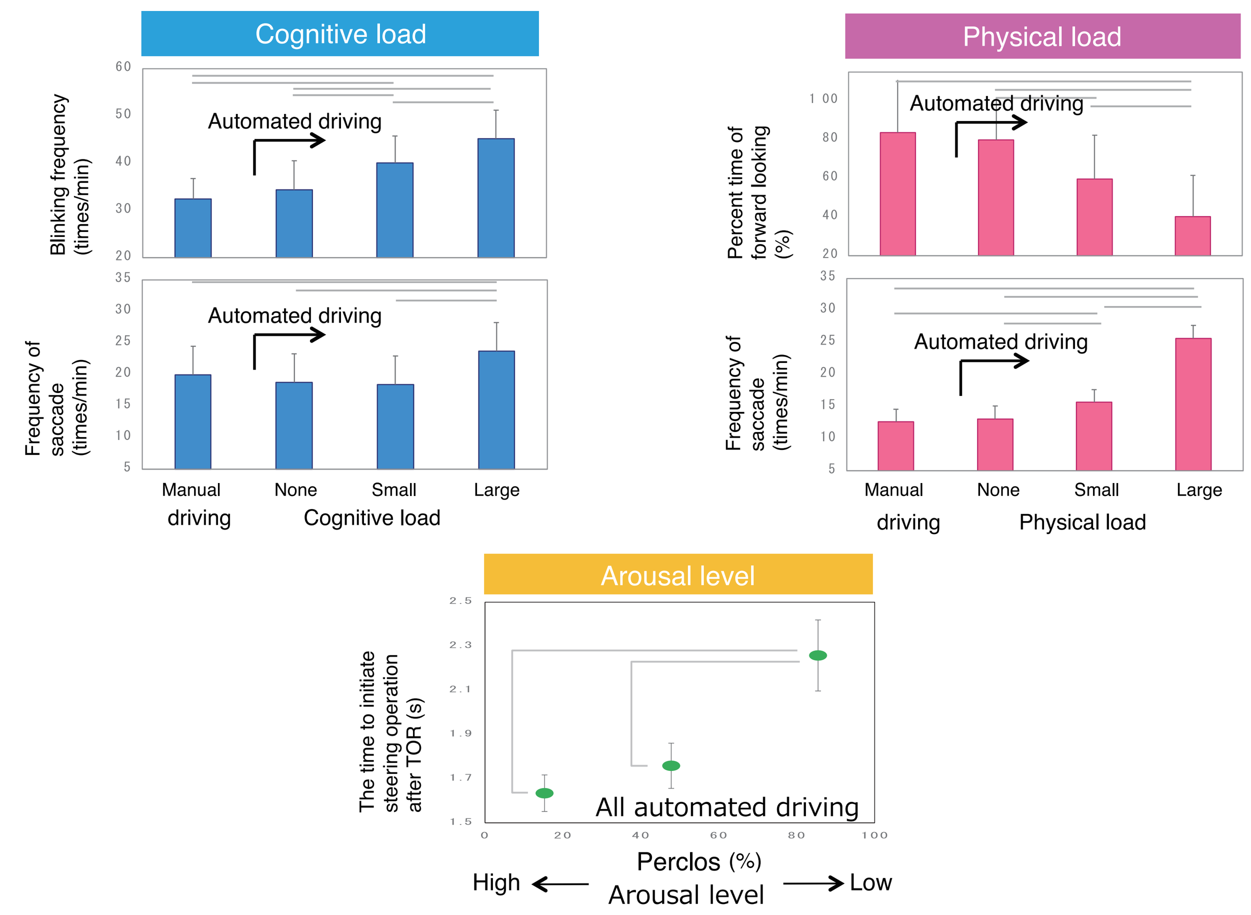

Figure 7 Physiological metrics correlated with the driver's state and the degraded driver's performance in transition.

3. Results

- Larger cognitive load given to the driver resulted in smaller minimum distance to the stationary vehicle in the event. Blinking frequency and frequency of saccade were metrics of driver state with the cognitive load.
- Larger physical load given to the driver resulted in larger variability in the steering angle after changing lane and longer time to stabilize the vehicle laterally. Percent time of forward looking and frequency of saccade were metrics of driver state with the physical load.
- Lower arousal level of the driver resulted in longer time to initiate steering operation after TOR. Perclos was the metric of driver state in terms of arousal level.

4. Conclusions

- Cognitive load, physical load and arousal level while driving with the system all influenced driver' s transition behavior in different ways.
- Physiological metrics of driver state were extracted.

Task C

1. Aim (Year 1)

To study non-verbal communication between drivers (D2D) and between driver and pedestrians (D2P).

2. Experiment 1 (D2D): Method

Communication behavior between drivers was observed and recorded in the instrumented vehicle driven by the subjects. A total of 41 subjects participated in the experiment.

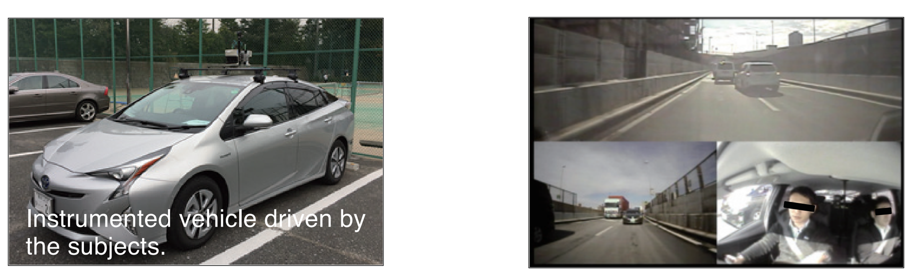

Figure 8 The instrumented vehicle and the video images taken by the cameras.

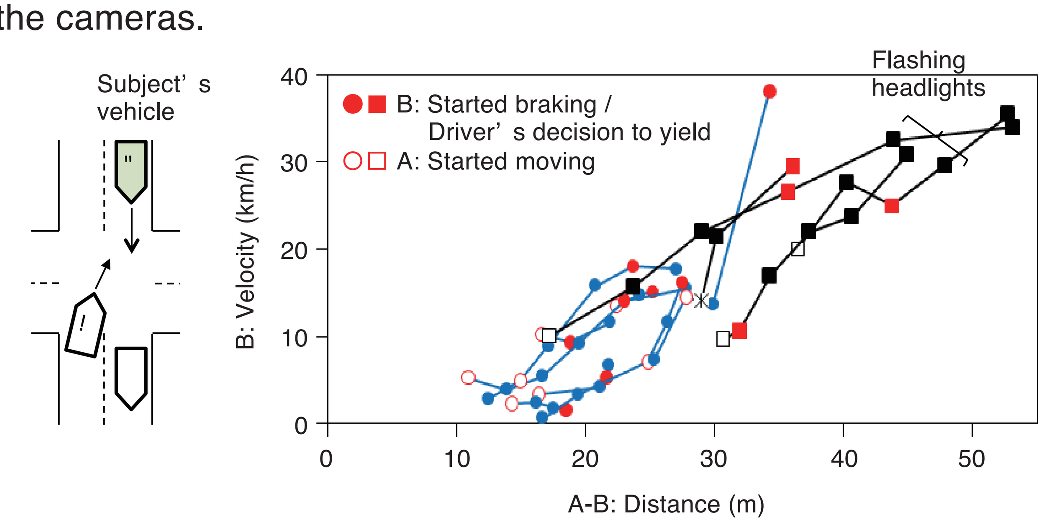

Figure 9 Behaviors of two vehicles in communication.

3. Experiment 1: Results

- Car A started moving when Car B slowed down to 15 or less km/h with the distance less than 30m.
- Car A started moving earlier with the distance more than 30m when Car B flashed the headlights with slowing down.

4. Experiment 2 (D2P): Method

The subject stood as a pedestrian on the road in the closed field and made a judgement to cross the road when a vehicle is approaching in various speed and deceleration. The subjects included 5 younger male subjects (from 23 to 32 y.o.), older male subjects (from 65 to 71 y.o.), and 3rd and 4th grade elementary school students.


Figure 10 The experiment in the closed field.

5. Experiment 2 (D2P): Results

- Pedestrians made a decision to cross the road when the car approached at very low speed (5km/h).
- Deceleration gave more confidence to the pedestrians to cross the road especially to the older pedestrians.
- Flashing headlights gave an additional signal to yield, resulting in lager decision distance both for the constant speed and slowing down conditions except for the older pedestrians.

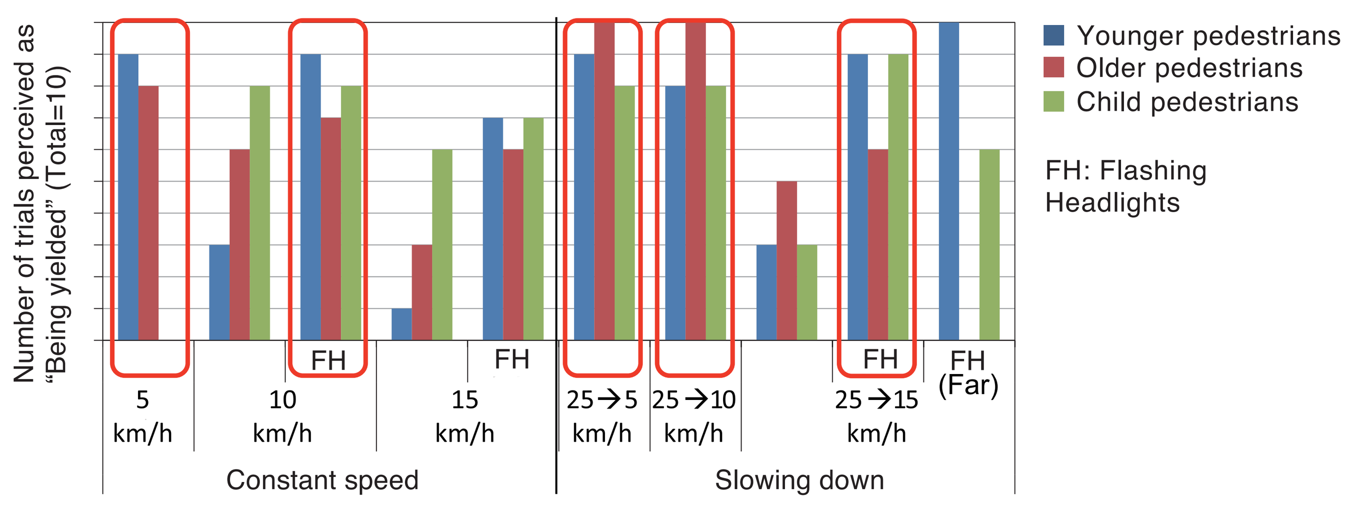

Figure 11 Pedestrians' judgement to cross the road for different profiles of the approaching vehicle.

6. Conclusions

- Vehicle behavior was the primary communication signal when yielding to other road users (drivers and pedestrians). Profiles of vehicle behavior as the communication signal were estimated quantitatively.
- Flashing headlights gave an additional signal to yield, resulting in lager decision distance (earlier decision timing) for other road users. It may be replaced by the external HMI of AV.

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